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CONTENTS

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All correspondence in connection with this Journal should be addressed to: The Secretary, East Africa Natural History Society, P.O. Box 4486, Nairobi, Kenya.

CYPERACEAE OF EAST AFRICA - III

By

D.M. NAPPER

FICINIA Schrad.

Southern Africa is the main centre of distribution for the numerous species of Ficinia. Only two out of over 60 species have been recorded as occurring in eastern Africa, the remainder are endemic in the southern part of the continent. These two species can be found in the upland and montane grass or ericaceous moorlands, there are few records below 8,000 ft.

Both species show a marked resemblence to those Bulbostylis species with dense capitate inflorescences, slender culms and setaceous glabrous leaves, but they may be readily distinguished by the stout, usually elongated woody rhizome and by the nutlet. Spikelet structure is as in Bulbostylis. The styles are 3-fid. The nutlets are trigonous and smooth with a fine gynophore similar to those seen in Scleria, which is often difficult to see at magnifications less than x20, and a persistent but rarely swollen style-base similar to those of Bulbostylis and Fuirena.

Key to Species

1. Plant and glumes glabrous; the style branches in the lower half; nutlets smooth 2
   Plant and glumes finely pubescent or hairy; style entire for over half its length; nutlets wrinkled ..... Bulbostylis atrosanguinea

2. Leaves very fine; heads of 1 - 6 spikelets..... 1. F. filiformis
   Leaves setaceous, stiff; heads of 6 - 20 spikelets. 2. F. gracilis

1. F. filiformis Schrad. (Fig. 12)
   Glabrous perennial up to 10 ins. high with a woody rhizome. Head blackish brown, 5 - 10 mm diam. with 4 - 7 mm long spikelets. Anthers less than 2 mm long. Steep rocky hillsides, grassland and moorland; 6,000 - 11,000 ft.
TANGANYIKA - Longido, Kilimanjaro, Usambara Mts., Rungwe and the Elton Plateau.

2. F. gracilis Schrad. (Fig. 13)
   Glabrous perennial up to 18 ins. high with a woody rhizome. Head chestnut or brown, 15 mm diam. with numerous 3 - 9 mm long spikelets. Anthers less than 2 mm long. In Protea, Erica and grass moorland; 8,000 - 15,000 ft.
KENYA - Mt. Kenya.
TANGANYIKA - Kilimanjaro, Uluguru Mts., and Rungwe.

BULBOSTYLIS Kunth ex C.B. Clarke

Bulbostylis is quite a large genus with a pantropical and warm temperate distribution, and is especially abundant in Africa and America. Most of the species occur in damp hollows and similar places in upland grassland, on rocky outcrops or in open woodland at altitudes of 3,000 - 12,000 ft., though some species are found in similar habitats down to sea level.

Characteristically of a nondescript tufted habit, both annual and perennial species with rather woody bases occur, but the elongated woody rhizomes typical of Ficinia do not occur. All species have narrow setaceous or filiform leaves, hairy in some species and glabrous in others, but usually with tufts of long hairs at the mouths of the sheaths. The inflorescence may be a solitary dense terminal head with 2 - 3 short subtending bracts, sometimes with 1 - 2 secondary heads arising from the base of the primary one, or it may be umbelliform with 1 or several sessile spikelets at the base and a number of pedicelled solitary ones. The latter form of inflorescence also occurs on plants of similar habit in Fimbristylis and such species can be confused unless the nutlets are carefully examined. The spikelets have numerous spirally arranged glumes of which the lowest 1 - 2 are empty, the succeeding ones are bisexual (with nutlets) and the uppermost are male or sterile. All species have a 3-fid style with the exception of B. humilis in which it is 2-fid. The base of the style is swollen and persists on the maturing nutlet as a dark knob. The nutlet is usually more or less obovoid in shape with a smooth or transversely wrinkled (wavy) surface. More rarely it is longitudinally striate as in Scirpus.

Key to Species

1. Inflorescence a solitary spikelet 2
   Inflorescence a dense head of several spikelets, or umbelliform 4

2. Small tufted annual 3
   Densely tufted perennial with a woody base..... 10. B. zambesica

3. Spikelets 5 mm long, or more ..... 1. B. humilis
   Spikelets 2 - 4 mm long ..... 15. B. glaberrima

4. Heads solitary and dense with sessile spikelets, secondary heads sometimes present 5
   Inflorescence looser, umbelliform, with most of the spikelets pedicelled and solitary 12

5. Nutlets longitudinally ribbed ..... 7. B. schimperiana
   Nutlets smooth or transversely wrinkled 6

6. Spikelets very large, 13 - 18 mm long, light brown and shiny ..... 20. B. aphyllanthoides
   Spikelets not over 12 mm 7

7. Spikelets very acute 8
   Spikelets obtuse or subacute 10

8. Slender annual 4 - 11 ins. high 9
   Tufted perennial 9 - 18 ins. high ..... 4. B. cardiocarpa

9. Nutlets transversely wrinkled ..... 2. B. buchananii
   Nutlets smooth ..... 3. B. barbata

10. Heads blackish red, up to 20 mm diam. 11
    Heads light brown, up to 15 mm diam. ..... 6. B. boeckeleriana

11. Spikelets up to 5 mm long ..... 8. B. trichobasis
    Spikelets 5 - 20 mm long .....5. B. atrosanguinea

12. Spikelets large, 5 - 8 mm long 13
    Spikelets small, up to 5 mm long 18

13. Plant sparingly hairy all over, especially just below the umbel 15
    Plant with glabrous stems 14

14. Nutlets transversely wrinkled ..... 8. B. trichobasis
    Nutlets longitudinally striate ..... 9. B. johnstonii

15. Leaves half the length of the stem; spikelets numerous 16
    Leaves very short or absent; spikelets few ..... 19. B. transiens

16. Glumes densely pubescent, whitish ..... 17. B. argenteobrunnea
    Glumes glabrous, brown 17

17. Glumes dark, an inland species ..... 16. B. coleotricha
    Glumes light brown, a coastal species .....
    ..... 18. B. sp. near B. argenteobrunnea

18. Stems hairy, at least at the tip 19
    Stems glabrous throughout 20

19. Stems up to 6 ins. high; inflorescence of 1 - 2 spikelets ..... 13. B. filiformis
    Stems 4 - 18 ins. high; inflorescence of numerous spikelets ..... 12. B. holotricha

20. Leaves setaceous .....14. B. densa
    Leaves filiform ..... 11. B. abortiva

1. B. humilis Kunth (Fig. 2)
   (Including B. striatella C.B.Cl.)
   Small leafy glabrous annual 2 - 8 ins. high. Spikelets solitary, occasionally paired, 5 - 8 mm long with light brown, mucronate, green-keeled glumes. Style 2-fid. Nutlet smooth or faintly longitudinally striate. Upland grassland, a weed; 6,000 - 9,000 ft.
KENYA - West Rift Highlands.
TANGANYIKA - Northern Region.

2. B. buchananii C.B.Cl. (Fig. 6)
   Slender glabrous annual up to 9 ins. high. Head solitary, dense, 5 - 9 mm diam. Spikelets light brown, 5 - 6 mm long with mucronate glumes. Nutlets finely wrinkled. Grassland, rocky outcrops and open

bush; 2,500 - 6,000 ft.
KENYA - Rift Valley.
TANGANYIKA - Western and Central Regions.

3. B. barbata (Rottb.) C.B.Cl.
Slender glabrous annual up to 9 ins. high. Head solitary, dense, up to 8 mm diam. Spikelets similar to B. buchananii from which it can scarcely be distinguished except by the smooth nutlet. Rocky outcrops, grassland and open bush; sea level - 1,000 ft.
TANGANYIKA - Southern Region and the Coast.
ZANZIBAR - Zanzibar Island.

4. B. cardiocarpa (Ridley) C.B.Cl.
Densely tufted perennial 9 - 18 ins. high with filiform leaves. Heads solitary on glabrous stems, 8 - 12 mm diam. Spikelets 10 - 20, dark brown, 10 mm long with mucronate acute glumes. Nutlets smooth. Grassland, stony hillsides and open woodland; 4,500 - 5,000 ft.
KENYA - Rift Valley.
TANGANYIKA - Lake and Western Regions.
B. filamentosa (Vahl) C.B.Cl., a very similar species with finely hairy stems and different nutlets, is said to occur in East Africa but I have yet to see specimens of it.

5. B. atrosanguinea (Boeck.) C.B.Cl. (Fig. 17)
Densely tufted wiry perennial up to 1½ ft. high with minutely hairy leaves. Head solitary, up to 20 mm diam. with 2 - 20 black spikelets with obtuse glumes. Anthers 2 - 3 mm long. Nutlets faintly wavy. Readily confused with Ficinia. Damp grassland, rocky outcrops etc.; 6,000 - 12,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Northern, Western and Southern Highland Regions.
UGANDA - Buganda, Karamoja.

6. B. boeckeleriana (Schweinf.) A.A. Beetle (Figs. 10, 11, 18)
(B. collina pro parte, B. collina Kunth. var. boeckeleriana (Schweinf.) Chiov., B. zeyheri auctt., B. vaginosa Kukenth.)
Densely tufted perennial up to 1½ ft. high with the stems crowded on a woody rhizome. Heads up to 15 mm diam. solitary or with 1 - 3 smaller lateral pedicelled heads. Spikelets 6 - 8 mm long with light brown green-keeled mucronate glumes. Nutlets wavy. In grassland and on rocky hillocks; 3,500 - 8,000 ft.
KENYA - Widespread on mountains and in upland areas.
TANGANYIKA - Northern, Western and Southern Highland Regions.
UGANDA - Western, Buganda and Eastern Provinces.

7. B. schimperiana (Hochst.) C.B.Cl. (Fig. 16)
Annual or slender tufted perennial 4 - 15 ins. high with setaceous leaves. Heads solitary, up to 10 mm diam. with reddish brown minutely hairy obtuse glumes. Nutlets longitudinally striate and faintly wavy. Damp grassland and shallow soils on rocky outcrops; 3,000 - 5,000 ft.
TANGANYIKA - Lake and Western Regions.
UGANDA - Eastern Province and Buganda.

8. B. trichobasis C.B.Cl.
(B. caespitosa A. Peter)
Slender tufted glabrous perennial 6 - 12 ins. high with bulbous stem-bases closely packed on a short rhizome. Spikelets 3 - 10, shortly pedicelled or sessile, 6 mm long with dark brown or black

pubescent glumes. Nutlets transversely wavy. Seasonally swampy grassland; 3,000 - 7,000 ft.
KENYA - Limuru area.
TANGANYIKA - Western Region and the Usambara Mts.
UGANDA - Western Province and Karamoja.

9. B. johnstonii C.B.Cl.
Slender tufted annual 4 - 10 ins. high. Inflorescence a simple umbel of up to 5 solitary 5 mm long spikelets. Glumes rusty brown, pubescent, often with a few long white hairs. Nutlets almost smooth, faintly lengthwise striate. Damp places in open bush; 4,000 - 6,000 ft.
TANGANYIKA - Kilimanjaro.

10. B. zambesica C.B.Cl.
Slender perennial 4 - 12 ins. high forming very dense tufts. Inflorescence a single large spikelet 8 - 10 mm long with minutely hairy glumes. Nutlets small, smooth or transversely wavy. Upland grassland, swampy places and rocky outcrops; 3,000 - 6,500 ft.
TANGANYIKA - Western, Eastern, Southern Highland and Southern Regions.

11. B. abortiva (Steud.) C.B.Cl.
Slender annual ½ - 2 ft. high with filiform (threadlike) leaves. Inflorescence a simple or compound umbel with numerous spikelets 3 - 5 mm long. Glumes glabrous, light brown. Nutlets faintly transversely wrinkled. In open thicket on stony hillsides; 2,000 - 4,000 ft.
TANGANYIKA - Northern and Western Regions.

12. B. holotricha A.Peter (Fig. 1)
Tufted annual 4 - 18 ins. high with hairy stems, leaves and inflorescence. Inflorescence a compound umbel with pedicelled solitary brown 3 - 4 mm long spikelets with obtuse brown pubescent glumes. Nutlets transversely wrinkled. Very similar to B. abortiva except for the indumentum. Frequent weed, in damp places usually on black cotton soils; 4,000 - 5,000 ft.
KENYA - Central Region and Nairobi.
TANGANYIKA - Western, Central and Southern Regions.

13. B. filiformis C.B.Cl.
Slender pubescent hairy annual 1 - 6 ins. high. Inflorescence of 1 or 2 spikelets 2.5 - 4 mm long with black, green-keeled pubescent glumes. Nutlets faintly transversely wrinkled. Differs from B. densa in hairiness and the fewer larger spikelets. Damp places; sea level - 5,000 ft.
KENYA - Eastern and coastal areas.
UGANDA - Western Province and Karamoja.

14. B. densa (Wall.) Hand.-Mazz. (Fig. 9)
(B. capillaris (L.) C.B.Cl. var. trifida (Nees) C.B.Cl.,
B. trifida (Nees) Nelmes)
Densely tufted slender annual up to 12 ins. high with setaceous leaves. Spikelets in a simple or compound umbel, rarely few, 2 - 3 mm long with pubescent, green-keeled brown glumes. Nutlets smooth or faintly transversely wavy. Rocky outcrops, damp places, grassland; 3,500 - 10,000 ft.
KENYA - Western and Rift Valley Regions.
TANGANYIKA - Northern and Western Regions, the Usambara and Uluguru Mts.
UGANDA - Western and Eastern Provinces.

15. B. glaberrima Kukenth. (Fig. 3)
Slender tufted annual up to 2 ins. high with curving stems and leaves. Inflorescence a single dark brown spikelet 2 - 3.5 mm long. Nutlets smooth. Stream banks in mountain moorland; 10,000 - 12,000 ft.
KENYA - Aberdare Mts.

16. B. coleotricha (A. Rich.) C.B.Cl.
(B. lanifera (Boeck.) A. Peter)
Tufted perennial 6 - 18 ins. high with stems hairy at the top. Umbel of 3 to many spikelets 6 - 8 mm long with dark brown obtuse green-keeled glumes. Nutlets smooth or obscurely wavy. Very like Fimbristylis exilis. Damp places; 2,000 - 6,000 ft.
KENYA - Western, Rift Valley and Central Regions, Nairobi and Masailand.

17. B. argenteobrunnea C.B.Cl.
Slender tufted perennial 6 - 18 ins. high, glabrous or finely pubescent. Inflorescence a pubescent umbel of 5 - 7 mm long spikelets. Glumes very pale 2.5 - 3.5 mm long, mucronate, densely pubescent. Nutlets wavy. Thorn bush and rocky outcrops.
KENYA - Eastern areas.

18. B. species near B. argenteobrunnea C.B.Cl.
Tufted perennial very similar to the above but with darker 7 - 12 mm long spikelets and more sparingly pubescent green-keeled glumes 4 - 5 mm long. Damp places; sea level - 1,500 ft.
KENYA - Coast.
TANGANYIKA - Coast.

19. B. transiens (K.Schum.) C.B.Cl.
Tufted annual similar to B. coleotricha but with very reduced leaves. Spikelets few with pale brown pubescent glumes. Nutlets strongly wrinkled transversely. Sea level - 2,000 ft.
TANGANYIKA - Tanga Region.

20. B. aphyllanthoides (Ridl.) C.B.Cl. (Fig. 19)
Stout tufted leafy perennial 1 - 2½ ft. high. Inflorescence a dense head with 6 - 7 shining brown sessile spikelets 8 - 15 mm long. Glumes 3 - 4 mm long. Nutlets obscurely wavy. Partial shade in bush and plantations; sea level - 4,000 ft.
KENYA - Coast.
TANGANYIKA - Western and Central Regions and the Coast.
ZANZIBAR - Zanzibar Island.

FIMBRISTYLIS Vahl

Fimbristylis is a large genus of pantropical and warm temperate distribution which is especially abundant in Malaysia and Australia. The score or so of species occurring in East Africa show a wide range of habitat, some occur in stony grassland or open bush with species of Bulbostylis of similar habit, while others, stouter in appearance, are found in swamps or on sandy shores over a wide range of altitude.

Both annual and perennial species occur, most of which are tufted with leaves developed at the base of the flowering stems only but one or two are rhizomatous. The species found in the drier habitats have fine setaceous leaves similar to Bulbostylis and an umbellate inflorescence. The swamp and sea-shore species are usually much stouter

with flat linear leaves or leaves reduced to the sheaths only. In most species the inflorescence is a compound umbel, but in a few this is reduced to a solitary spikelet. The majority of species have spikelets with spirally arranged glumes, but in the section Abildgaardia (species 1 and 2), which some authors have treated as a distinct genus, the glumes are distichously arranged, at least in the lower part of the spikelet, and are much larger than normal for the genus and shining. The lowest 1 - 2 glumes are empty, the succeeding ones are bisexual (with nutlets) and the uppermost are male or sterile. The style is 2-fid or 3-fid with an enlarged non-persistent base which is distinct from the nutlet and falls with the style. The nutlets are biconvex or trigonous according to the number of style-arms, with a smooth, transversely wrinkled or warted surface.

Key to Species

1. Spikelets strongly laterally compressed, few; at least the lower glumes distichously arranged 2
   Spikelets not compressed, few or many; glumes spirally arranged 4

2. Spikelets solitary ..... 1. F. monostachyos
   Spikelets several 3

3. Spikelets umbelled ..... 2. F. triflora
   Spikelets in a dense head ..... Bulbostylis aphyllanthoides

4. Inflorescence a solitary spikelet (resembling Eleocharis) ..... 18. F. polytrichoides
   Inflorescence of several spikelets 5

5. Stigmas 2; style flat, often bearded; nutlet biconvex 15
   Stigmas 3; style triquetrous, usually glabrous; nutlet trigonous (a tendency to digyny is found in some species) 6

6. Leaves of the flowering stems (at least the upper ones) reduced to bladeless sheaths, numerous long basal leaves often present 7
   All stem leaves with well developed blades 9

7. Spikelets numerous, 2 - 5 mm long, with obtuse glumes up to 1.5 mm long; leaves filiform, usually short ..... 10. F. miliacea
   Spikelets numerous, usually rather larger with glumes over 2 mm long; leaves flat with a distinct midrib 8

8. Basal leaves well developed; spikelets obtuse; annual .....11. F. quinquangularis
   Stiff perennial with bladeless leaves, or rarely a few narrow rigid ones developed .... 12. F. subaphylla

9. Spikelets always single, never clustered 12
   Spikelets in sessile or pedicelled clusters, a few solitary pedicelled spikelets often present 10

10. Slender annuals; inflorescence a sessile cluster, rarely with 1 or 2 solitary pedicelled spikelets as well 11
Tufted perennial; inflorescence umbellate with pedicelled clusters of spikelets ..... 9. F. obtusifolia

11. Spikelets small, obtuse; glumes black, 1 - 1.5 mm long ..... 6. F. humilis
Spikelets subacute; glumes black with green keels, 2.5 - 3 mm long ..... 8. F. oligostachys

12. Spikelets fewer than 12 in each umbel; leaves filiform or setaceous; stems terete, ridged 13
Spikelets numerous, more than 12 in each umbel; leaves flat; stem compressed at the top, 2-angled ..... 7. F. complanata

13. Spikelets 10 mm long or more at maturity; perennial with bulbous swollen culm-bases clothed with fibrous remnants of old sheaths...4.F. chevalieri
Spikelets 5 - 8 mm long at maturity; culm-bases not swollen 14

14. Spikelets brown, elliptic, 6 - 8 mm long..... 3. F. exilis
Spikelets almost black, subglobose, 5 - 6 mm long ..... 5. F. rotundata

15. Ligules absent; glumes with a conspicuous recurved awnlike mucro ..... 19. F. squarrosa
Ligule a dense fringe of short hairs; glumes without a conspicuous mucro 16

16. Nutlets smooth; leaves reduced to the sheaths or absent 17
Nutlets wrinkled or warted; leaves present 18

17. Glumes grey and minutely pubescent above ..... 14. F. ferruginea
Glumes chestnut, glabrous and smooth ..... 13. F. longiculmis

18. Nutlets longitudinally striate; annual or tufted perennial 19
Nutlets warted; stoloniferous perennial..17. F. madagascariensis

19. Annual; spikelets 1 - 1.5 mm wide .....15. F. bisumbellata
Annual or perennial; spikelets 2 - 4 mm wide... 16. F. dichotoma

1. F. monostachyos (L.) Hassk. (Fig. 40)
(Abildgaardia monostachyos (L.) Vahl)
Tufted leafy perennial 3 - 18 ins. high. Spikelets solitary, 12 mm long with greenish white or yellowish glumes distichous below, spirally arranged above. Style 3-fid. Nutlets faintly warted. Wet grassland, vlei; sea level - 6,500 ft.
KENYA - Widespread and common.
TANGANYIKA - Lake, Tanga and Eastern Regions.
UGANDA - Western and Eastern Provinces.

2. F. triflora (L.) K. Schum. (Fig. 24)
(F. tristachya (Vahl) Thwaites)
Tufted leafy perennial 1 - 2½ ft. high. Spikelets 2 - 5 (rarely only 1), 20 - 25 mm long with pale glumes as in F. monostachya. Style 3-fid. Nutlets large, warted. Swampy grassland and salt marshes; sea level - 1,000 ft.
KENYA - Coast.
TANGANYIKA - Mafia Island and the Coast.
ZANZIBAR - Zanzibar and Pemba Islands.

3. F. exilis (H.B.K.) Roem. & Schult. (Figs. 23, 39)
Hairy tufted annual 4 - 18 ins. high, sometimes almost glabrous. Umbel of 3 - 14 spikelets 6 - 8 mm long with acute pubescent brown green-keeled glumes. Nutlets smooth or faintly wavy or warted. Very like Bulbostylis coleotricha in habit. Open woodland, grassland, damp places and seepage areas on rocky outcrops; sea level - 7,000 ft.
KENYA - Widespread.
TANGANYIKA - Widespread.
UGANDA - Widespread.
ZANZIBAR - Zanzibar Island.

4. F. chevalieri Kukenth.
Slender perennial up to 2 ft. high differing from the above chiefly in the tuberous swollen culm-bases. Spikelets rather larger, minutely hairy or glabrous with faintly wavy nutlets. Seasonally swampy places, rare; 3,000 - 5,000 ft.
TANGANYIKA - Western Region.

5. F. rotundata A. Peter
Sparingly hairy annual 4 - 15 ins. high. Inflorescence of 2 - 5 subglobose spikelets 5 - 6 mm long, 4 - 4.5 mm wide, one sessile, the others shortly pedicelled. Glumes obtuse, dark brown. Style 3-fid. Nutlets faintly warted.
TANGANYIKA - Western Region.

6. F. humilis A. Peter (Fig. 34)
Slender annual 4 - 10 ins. high. Inflorescence a dense 6 - 9 mm diam. cluster of black spikelets. Spikelets obtuse, 4 - 6 mm long, with pubescent, usually green-keeled glumes. Style 3-fid. Nutlets longitudinally striate. Damp places, saline pools, often a weed; 4,000 - 7,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Northern Region.

7. F. complanata (Retz.) Link (Fig. 38)
(Including F. keniaeensis Kukenth.)
Tufted perennial ½ - 2 ft high with rather greyish leaves up to 5 mm wide. Peduncles flattened above and winged. Umbel compound with many solitary brown spikelets 3 - 6 mm long. Style 3-fid. Nutlets faintly wavy or warted. Damp grassland and swamps; 5,000 - 9,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Northern and Tanga Regions.
UGANDA - Western Province.

8. F. oligostachys A.Rich. var. (Fig. 31)
Tufted annual up to 6 ins. high finely hairy throughout. Inflorescence a cluster of 2 - 6 spikelets up to 6 mm long with black, pubescent green-keeled glumes. Style 3-fid. Nutlets transversely wrinkled. Swampy stream banks; 7,000 - 8,000 ft.
KENYA - Western and Rift Valley Regions.
This Kenya form differs from the description of the species merely by being finely hairy throughout.

9. F. obtusifolia (Lam.) Kunth (Fig. 30)
Glabrous perennial 4 - 18 ins. high, rather stout. Umbel compound with small pedunculate clusters of 3 - 5 mm long spikelets with whitish obtuse glumes. Style 3-fid. Nutlets smooth and dark. Sandy shores and salt marshes; sea level.
KENYA and TANGANYIKA - Coast.
ZANZIBAR - Zanzibar Island.

10. F. miliacea (L.) Vahl (Fig. 25)
Tufted leafy annual ½ - 2 ft high usually with very short leaves. Umbel compound with numerous pedicellate globose or shortly cylindric 2 mm long spikelets. Style 3-fid. Nutlets faintly warted or wavy. Swampy grassland; sea level - 1,000 ft.
TANGANYIKA - Coast.
ZANZIBAR - Zanzibar Island.

11. F. quinquangularis (Vahl) Kunth
Glabrous annual similar to the above but with broader, often very short leaves. Umbel compound with numerous pedicellate spikelets 3 - 5 mm long. Style 3-fid. Nutlets faintly wavy or warted.
TANGANYIKA - Lake Region.

12. F. subaphylla Boeck.
Tufted glabrous perennial with leaf-blades very short or absent. Umbels compound, very similar to F. complanata with brown ellipsoid obtuse spikelets 4 - 8 mm long. Style 3-fid. Nutlets smooth or warted, rarely wavy. In swamps; 3,000 - 4,000 ft.
UGANDA - Buganda.

13. F. longiculmis Steud. (Fig. 22)
Tufted leafless perennial 2 - 4 ft high. Umbels compound with numerous brown obtuse glabrous spikelets 10 - 20 mm long. Styles 2-fid. Nutlets smooth. Very similar to F. ferruginea. Swamps and sea shore; sea level.
TANGANYIKA - Mafia Island and the Coast.
ZANZIBAR - Zanzibar Island.

14. F. ferruginea (L.) Vahl
Tufted perennial 3 - 5 ft high with greyish leaves often reduced to the sheaths only and culms compressed towards the tip. Umbels compound with numerous brownish spikelets 10 - 20 mm long differing from F. longiculmis only in the greyish pubescence on the back of the glumes. Styles 2-fid. Nutlets smooth. Sandy beaches; sea level.
KENYA - Coast.
TANGANYIKA - Coast.
ZANZIBAR - Zanzibar Island.

15. F. bisumbellata (Forsk.) Bub.
Tufted leafy annual 4 - 10 ins. high with greyish pubescent leaves. Umbel compound with numerous 3 - 5 mm long spikelets. Style 2-fid. Nutlets longitudinally striate. Sandy places on river banks; sea level - 3,000 ft.
KENYA - Central Region.
TANGANYIKA - Tanga, Central and Southern Regions.

16. F. dichotoma (L.) Vahl (Fig. 28)
(F. diphylla (Retz.) Vahl)
Tufted perennial or annual ½ - 2½ ft high with greyish often pubescent leaves. Umbels compound with numerous spikelets on a compressed but not winged peduncle. Spikelets up to 10 mm long, brown.

Style 2-fid. Nutlets longitudinally striate. River banks, forests, swamps etc.; sea level - 5,500 ft.
KENYA - Widespread.
TANGANYIKA - Widespread.
UGANDA - Widespread.
ZANZIBAR - Zanzibar Island.

17. F. madagascariensis Boeck. (Fig. 24)
(F. dichotoma pro parte)
Stoloniferous perennial up to 2½ ft high differing from the above only in the presence of stolons, the slightly larger spikelets and the warted nutlets. Swampy grassland; 3,000 - 7,000 ft.
KENYA - Nairobi.
TANGANYIKA - Lake and Western Regions.

18. F. polytrichoides R.Br.
Tufted glabrous leafy perennial 6 - 15 ins. high. Spikelets solitary, with pale obtuse glumes. Style 2-fid. Nutlets smooth. Sandy places, sometimes a weed; sea level - 4,000 ft.
KENYA - Coast.
TANGANYIKA - Lake Region and the Coast.
ZANZIBAR - Zanzibar Island.

19. F. squarrosa (Poir.) Vahl (Figs. 35, 36)
Slender leafy annual 2 - 8 ins. high. Umbel compound with small straw-coloured spikelets, the glumes with a strongly recurved mucro. Style 2-fid with slender processes descending from its base and surrounding the smooth nutlet. This species has the habit of a small Mariscus or Cyperus but the glumes are spirally arranged and the spikelets are not compressed. Swamps and damp grassland; sea level - 4,000 ft.
TANGANYIKA - Lake Region and the Coast.

SCIRPUS L.

Scirpus is a large, ill-defined genus with a world-wide distribution. Only a limited number of species are to be found in tropical East Africa in damp places, swamps and rivers over a wide range of altitude.

There is a wide range of habit among the annual and perennial species recorded here. Some have leafy stems (S. fluitans), some have the leaves restricted to the base of the stems and in yet others the leaves are reduced to the sheaths only. With the exception of S. fluitans all have conspicuous bracts subtending a terminal inflorescence which in the sections Isolepis (species 3 - 8) and Scirpus (species 9 - 17) are solitary, erect, and appear to be a continuation of the stem with the inflorescence appearing lateral. In most of the remaining species the bracts are usually leaflike and more numerous. The inflorescence is usually umbelliform, but it may be contracted into a dense head, while in a few species it is reduced to a solitary spikelet. The spikelets have spirally arranged glumes of which the lowest 0 - 2 are empty, the succeeding ones bisexual (with nutlets) and the uppermost male or sterile. Hypogynous bristles may be absent, linear-scabrid or plumose (S. littoralis). The style is 2-fid or 3-fid and passes gradually into the nutlet. The nutlets, which are trigonous or biconvex according to the number of style arms, may have a smooth, transversely wrinkled or longitudinally striate surface.

Key to Species

1. Inflorescence a solitary dense head or a single spikelet 2
   Inflorescence a compound umbel 18

2. Plants leafy 3
   Plants leafless, the leaves reduced to sheaths only 10

3. Spikelets 1 - 4, usually solitary 5
   Spikelets numerous in a single head, not distinct 4

4. Heads white, up to 5 mm diam. ..... 19. S. microcephalus
   Heads greenish, 6 - 10 mm diam. ..... 18. S. steudneri

5. Stems many-noded, creeping; spikelets solitary ... 3. S. fluitans
   Stems without nodes, erect 6

6. Spikelets 1 - 3 mm long; glumes not over 1 mm long 8
   Spikelets 2 - 3.5 mm long; glumes 1.2 - 2.5 mm long 7

7. Spikelets solitary or paired; annual 1 - 6 ins. high ..... 4. S. setaceus
   Spikelets clustered, 2 - 4; perennial 6 - 10 ins. high ..... 7. S. trollii

8. Spikelets solitary, apparently lateral, with a long erect bract ..... 6. S. isolepis
   Spikelets 2 - 4 in a terminal head 9

9. Bracts 1 - 3, scarcely longer than the spikelets; glumes mucronate ..... 5. S. sp. near S.isolepis
   Bracts long; glumes aristate ..... 20. S. lugardii

10. Stems triangular in section ..... 11. S. mucronatus
    Stems terete 11

11. Nutlets longitudinally striate and wavy 12
    Nutlets smooth or transversely wrinkled 13

12. Stems 0.7 - 1 mm diam.; heads 7 - 10 mm diam ..... 8. S. costatus var. costatus
    Stem up to 0.5 mm diam.; heads 4 - 6 mm diam ..... 8. S. costatus var. macer

13. Spikelets small, up to 4 mm long ..... 12. S. tenerrimus
    Spikelets over 4 mm long 14

14. Spikelets very obtuse, lanceolate, with glume margins usually inrolled; culms transversely septate 15
    Spikelets linear, glumes not incurved; culms not septate 16

15. Spikelets 6 - 8 mm long, greenish yellow..... 9. S. praelongatus
    Spikelets 10 - 12 mm long, streaked with red or brown ..... 10. S. articulatus

16. Nutlets strongly transversely wrinkled 17
Nutlets smooth or faintly wavy ..... 13. S. roylei

17. Annual; spikelets 5 - 6 mm long, glumes 2.5 - 3 mm long..... 14. S. supinus
Perennial; spikelets 5 - 12 mm long; glumes 2.5 - 4.5 mm long..... 15. S. confusus

18. Stems triangular with acute angles 19
Stems terete, sometimes faintly angled at the top 20

19. Spikelets crowded in dense spherical heads 10 - 15 mm wide ..... 1. S. cubensis
Spikelets linear-lanceolate, 10 - 35 mm long.... 2. S. maritimus

20. Spikelets cylindric-linear, 10 - 35 mm long .... 17. S. littoralis var. pterolepis
Spikelets up to 10 mm long 20

21. Umbel compound; nutlets smooth or faintly wavy; bracts shorter than the inflorescence ..... 16. S. inclinatus
Umbels contracted with very short branches; nutlets strongly wrinkled; bracts much longer than the inflorescence ..... 15. S. confusus

1. S. cubensis Kunth (Figs. 44, 55)
Tufted leafy perennial up to 2 ft high. Inflorescence of dense round pedunculate heads. Spikelets 4 - 8 mm long with acute, ciliate-margined green glumes. Style 2-fid. Nutlets smooth, beaked. Stream banks, and swamps; sea level - 4,000 ft.
TANGANYIKA - Mafia Island.
UGANDA - Buganda.

2. S. maritimus L. (Fig. 43)
Glabrous leafy perennial 1 - 4 ft high. Inflorescence of ovate or linear spikelets with golden-brown long-mucronate glumes. Style 2-fid or 3-fid. Nutlets smooth or faintly reticulate. Seasonal pools, river banks, rice fields; sea level - 5,500 ft.
KENYA - Central Region and the Coast.
TANGANYIKA - Northern, Central, Tanga Regions and the Coast.

3. S. fluitans L.
Creeping leafy herb with many-noded stems often rooting from the nodes. Inflorescence a solitary green spikelet 3 - 4 mm long. Style 2-fid. Nutlets smooth. Damp grassland, swampy places and pools; 4,000 - 14,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Lake, Northern, Tanga and Southern Regions.
UGANDA - Western and Eastern Provinces.

4. S. setaceus L. (Fig. 46)
Slender leafy annual 1 - 6 ins. high with solitary or clustered lateral spikelets 2 - 5 mm long. Style 3-fid. Nutlets longitudinally striate. There is a marked similarity with Bulbostylis but that genus never has lateral inflorescences. Swamps and stream banks; 9,000 - 12,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Northern Region.
UGANDA - Western Province.

5. S. species near S. isolepis (Nees) Boeck.
Slender annual 1 - 6 ins. high with short leaves, and a solitary lateral head of 2 - 3 spikelets. Spikelets 1 - 2.5 mm long with dark obtuse glumes. Style 3-fid. Nutlets smooth. Damp grassland and swampy places; 6,000 - 8,000 ft.
KENYA - Central Region.
TANGANYIKA - Southern Highlands Region.

6. S. isolepis (Nees) Boeck. (Fig. 52)
(Lipocarpha monocephala Turrill)
Very slender leafy annual 1½ - 6 ins. high with solitary lateral spikelets 2 - 3 mm long. Glumes purple, obtuse. Style 2-fid. Nutlets smooth. Of similar habit to Lipocarpha monostachya but lacks the awns. Swampy grassland; 5,000 - 7,500 ft.
KENYA - Western Region.
TANGANYIKA - Western and Central Region.

7. S. trollii Kukenth.
Tufted leafy perennial with lateral heads. Bract 20 - 50 mm long. Spikelets dark brown, 2.5 - 4 mm long, in sessile clusters of 2 - 4. Style 3-fid. Nutlets smooth. On mist forest edges, rare; 7,000 - 8,000 ft.
TANGANYIKA - Uluguru Mts.

8. S. costatus Boeck. var. costatus (Figs. 45, 47)
Slender shortly rhizomatous leafless perennial up to 2 ft high. Bracts short. Heads terminal, 7 - 10 mm diam. with few obtuse 3 - 6 mm long spikelets. Style 3-fid. Nutlets longitudinally striate and wavy. Mountains, bogs and swamps; 6,000 - 11,500 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Northern, Tanga and Southern Regions.
UGANDA - Western Province.

var. macer (Boeck.) Cherm.
Differs from the above only in being more slender, not over 18 ins. high. Swamps, stream banks and Sphagnum bogs; 7,000 - 10,000 ft.
KENYA - Western, Rift Valley and Central Regions.
TANGANYIKA - Widespread but not common.
UGANDA - Western Region.

9. S. praelongatus Poir. (Fig. 50)
Tufted leafless annual 1 - 2 ft high with terete septate stems, but the septa are rarely conspicuous. Inflorescence a lateral cluster of subobtuse golden spikelets borne about ⅓ of the way up the stem. Spikelets 4 - 6 mm long. Style 3-fid. Nutlets wavy. Seasonally swampy places; sea level - 4,000 ft.
KENYA - Widespread but uncommon.
TANGANYIKA - Western Region.
UGANDA - Western Province.

10. S. articulatus L.
Tufted leafless perennial 1 - 3 ft. high with stout septate stems. Spikelets in a lateral cluster, obtuse or subacute, pale or brownish, 6 - 15 mm long. Style 3-fid. Nutlets smooth or wavy. Pools, ditches and swamps; sea level - 3,500 ft.
KENYA - Coast.
TANGANYIKA - Lake Region, Coast.
UGANDA - Western and Eastern Provinces.
ZANZIBAR - Pemba and Zanzibar Islands.

11. S. mucronatus L. (Fig. 56)
Tufted leafless perennial up to 2½ ft high with stout triangular stems. Spikelets 10 mm long or more, in a lateral cluster. Styles 3-fid. Nutlets smooth or faintly wavy. Pools and swamps; 3,000 - 4,000 ft.
TANGANYIKA - Lake Regions.

12. S. tenerrimus A. Peter
Tufted leafless annual 6 - 12 ins. high very similar to S. costatus var. macer but having pale sheaths and glumes, a terminal bract 2 - 6 ins. long, and a strongly transversely wrinkled nutlet. Damp places 3,500 - 4,500 ft.
TANGANYIKA - Western Region.

13. S. roylei (Nees) A.A. Beetle (Fig. 49)
(Isolepis lupulina Wight, S. quinquefarius Boeck.)
Leafless tufted perennial 1 - 2 ft high. Inflorescence a lateral cluster of golden spikelets up to 8 mm long with spreading glumes. Style 3-fid. Nutlets smooth. Damp places; sea level - 5,000 ft.
KENYA - Central Region.
TANGANYIKA - Coast.

14. S. supinus L.
Leafless tufted annual up to 12 ins. high Spikelets 4 - 12 mm long in a lateral cluster, with green-keeled glumes. Style 3-fid. Nutlets strongly transversely wrinkled. Similar to S. confusus but more slender. Swampy places and rice fields; 1,000 - 4,000 ft.
TANGANYIKA - Northern Region.

15. S. confusus N.E.Br. (Fig. 48)
(S. supinus var. uninodis in Fl. Trop. Afr. partly, S. corymbosus var. junciformis A. Peter)
Tufted perennial 1 - 3 ft high. Inflorescence bract much longer than the inflorescence. Spikelets in shortly pedunculate umbels or sessile clusters, 5 - 12 mm long. Style 3-fid. Nutlets strongly transversely wrinkled. Swamps; 1,000 - 5,000 ft.
KENYA - Widespread but not very common.
TANGANYIKA - Northern, Central, Southern Highland and Southern Regions.
UGANDA - Western Province, Buganda and Karamoja.
ZANZIBAR - Zanzibar Island.

16. S. inclinatus (Del.) Aschers. & Schweinf. (Fig. 54)
(S. corymbosus auctt., S. corymbosus var. brachyceras (A. Rich.) Schweinf., S. brachyceras A. Rich.)
Stout-stemmed leafless perennial 1 - 8 ft high. Inflorescence bracts shorter than the inflorescence, rarely over 2½ ins. long. Inflorescence umbelliform with pedunculate and sessile clusters of 4 - 7 mm long spikelets. Style 3-fid. Nutlets smooth or faintly wavy. Swamps, rivers and lakes; 2,000 - 8,000 ft.
KENYA - Widespread.
TANGANYIKA - Widespread.
UGANDA - Western and Eastern Provinces.
The differences between S. inclinatus and S. brachyceras are so slight that there are inadequate grounds for maintaining them as distinct species.

17. S. littoralis Schrad. var. pterolepis (Kunth) C.B.Cl.
(Frequently confused with S. subulatus Vahl from which it may not be distinct).
Glabrous perennial 2 - 7 ft high, usually leafless. Stems stout, terete or triangular at the top. Umbel compound with numerous pedicelled subcylindric spikelets 10 - 12 mm long. Hypogynous bristles plumose. Style 2-fid. Nutlets smooth. Swamps, rivers and lake shores; 3,000 - 5,500 ft.
KENYA - Western Region.
TANGANYIKA - Lake and Southern Highland Regions.

18. S. steudneri Boeck. (Fig. 53)
Slender leafy glabrous perennial surrounded at the base by fibrous sheath remnants. Heads terminal with several leafy bracts, 6 - 10 mm wide, with numerous greenish spikelets. Glumes with recurved mucros. Styles 3-fid. Nutlets smooth. Easily mistaken for Kyllinga. Swampy places; 2,000 - 5,000 ft.
KENYA - Central and Northeastern Regions, Nairobi and the Coast.
TANGANYIKA - Lake, Central, Eastern and Southern Highland Regions.
UGANDA - Karamoja.

19. S. microcephalus (Steud.) Dandy
Tufted perennial 1 - 6 ins. high similar to the above but more slender. Heads terminal, minute, white. Style 3-fid. Nutlets smooth. Damp places; sea level - 1,000 ft.
KENYA - Mombasa.
ZANZIBAR - Zanzibar Island.

20. S. lugardii C.B.Cl.
Slender leafy annual 1 - 4 ins. high. Inflorescence a dense compound terminal head 12 mm diam., rarely umbellate. Spikelets up to 3 mm long, dark. Glumes with long recurving mucros. Style 3-fid. Nutlets smooth. Damp places; 3,000 - 4,000 ft.
TANGANYIKA - Western and Central Regions.

ELEOCHARIS R..Br.

Eleocharis (sometimes spelt Heleocharis) is a large genus of world wide distribution which is especially abundant in America. Only a few species occur in Eastern Africa. Though usually to be found in fresh water at the edges of lakes, dams, rivers etc. there is also one species occurring in the salt waters of mangrove swamps.

All are leafless glabrous erect herbs with a solitary terminal spikelet, but the habit varies from very slender annuals scarcely 2 ins. high to stout rhizomatous perennials 3 - 4 ft high. The spikelet is without a long subtending bract and has numerous spirally arranged glumes of which the lower ones are sometimes distichous as in Fimbristylis monostachyos. As in the other genera of this group, the lower glumes are empty, the succeeding ones are bisexual (with nutlets) and the uppermost are staminate or empty. The hypogynous bristles are present in some species but their occurrence and development is not constant and is of no value in a practical classification. The styles may be 2-fid or 3-fid. In some species this is constant but in others, especially the stout ones, it is variable. The style-base is enlarged and persistent as in Bulbostylis. The nutlets are biconvex or trigonous according to the number of style arms and their surface is smooth, longitudinally striate or transversely wavy.

Key to Species

1. Glumes not keeled, or scarcely so, 3 - 8 mm long; spikelets over 10 mm long; stout-stemmed perennials 2
   Glumes conspicuously keeled, 1 - 3 mm long; spikelets less than 10 mm long; annuals or perennials, but slender 5

2. Nutlets smooth 3
   Nutlets longitudinally striate and transversely wavy 4

3. Stems terete, with a few transverse septa conspicuous in the dried state ..... 1. E. dulcis
   Stems without septa, compressed above and sometimes keeled, but not winged ..... 4. E. marginulata

4. Stems rounded or subtriangular ..... 3. E. variegata
   Stems trigonous, the angles very acute ..... 2. E. acutangula

5. Stems compressed, sharply 2-keeled ..... 6. E. complanata
   Stems terete or quadrangular 6

6. Spikelets lanceolate or elliptic, 1 - 2 mm wide 7
   Spikelets ovoid or broadly triangular, 3 - 4 mm wide ..... 10. E. caribaea

7. Spikelets tinged with red or purple 8
   Spikelets golden-yellow or brown ..... 5. E. nigrescens

8. Very slender-culmed annual up to 3½ ins. high with pale sheath-bases; spikelets not over 2 mm long ..... 8. E. brainii
   Slender-culmed annual 2½ - 6 ins. high with reddish sheath-bases; spikelets 2 - 5 mm long 9

9. Glumes obtuse ..... 9. E. atropurpurea
   Glumes acute ..... 7. E. retroflexa

1. E. dulcis (Burm.f.) Trin. (Fig. 26)
   (E. plantaginea (Retz.) Roem. & Schult.)
   Stout stoloniferous perennial 1 - 4 ft high with terete stems. Spikelet 25 - 50 mm long, pale green. Glumes rounded, often edged with brown. Style 2- or 3-fid. Nutlets smooth. Seasonally flooded pans, lake shores etc.; 3,500 - 5,000 ft.
KENYA - Central Region.
TANGANYIKA - Northern and Southern Regions.
UGANDA - Sese Islands.

2. E. acutangula (Roxb.) Schult. (Figs. 29, 32, 41)
   (E. fistulosa auctt.)
   Stout stolonoferous perennial 1 - 3 ft. high. Spikelets 20 - 40 mm long with pale green glumes. Style 2- or 3-fid. Nutlets faintly longitudinally striate. Swamps, lakes and permanent water; sea level - 5,000 ft.
KENYA - Western and Central Regions.
TANGANYIKA - Lake, Northern, Western and Central Regions.
UGANDA - Western Province.
ZANZIBAR - Pemba Island.

3. E. variegata (Poir.) Presl
Stoloniferous perennial 1 - 2 ft high. Spikelets 20 - 30 mm long with pale green hyaline-margined glumes edged with brown. Style 2- or 3-fid. Nutlets longitudinally striate. Swamps, streams, and lake shores; 2,500 - 4,000 ft.
TANGANYIKA - Western and Southern Regions.
UGANDA - Buganda.

4. E. marginulata Steud.
Stoloniferous perennial 1 - 2 ft high with slender subterete culms. Spikelet lanceolate, 10 - 15 mm long with dark brown glumes. Style 3-fid. Nutlets smooth. Marshy meadows, swamps, ditches; 5,000 - 8,000 ft.
KENYA - Rift Valley and Central Regions.
TANGANYIKA - Usambara Mts..
UGANDA - Western Province.

5. E. nigrescens (Nees) Steud.
(E. hildebrandtii Boeck.)
Slender tufted annual 2 - 9 ins high with quadrangular stems. Spikelets rather small, 2 - 5 mm long with pale yellowish or light brown glumes. Style 3-fid. Nutlets smooth. Swamps and shallow water; sea level - 4,500 ft.
TANGANYIKA - Western and Central Regions.
ZANZIBAR - Zanzibar Island.

6. E. complanata Boeck. (Fig. 27)
Tufted annual 2 - 5 ins. high with rather wide, flattened stems. Spikelets 4 - 10 mm long with obtuse purple glumes with broad white margins. Style 3-fid. Nutlets smooth. Spikelets similar to E. atropurpurea. Seasonally wet places; 2,000 - 3,000 ft.
TANGANYIKA - Western Region.

7. E. retroflexa (Poir.) Urban
Tufted annual 2 - 4 ins. high. Spikelet 3 - 3.5 mm long with acute glumes more like those of Fimbristylis than the other species of Eleocharis. Style 3-fid. Nutlets not seen. Lake shores; 4,000 - 5,000 ft.
TANGANYIKA - Western Region.

8. E. brainii Svenson
Slender tufted annual 1 - 5 ins. high. Spikelet 1 - 3 mm long. Glumes pale but with dark patches on the sides. Style 3-fid. Nutlets longitudinally striate. Partially or wholly submerged in swampy places; 3,000 - 4,000 ft.
TANGANYIKA - Southern Region.

9. E. atropurpurea (Retz.) Presl (Fig. 37)
(Including the doubtfully distinct E. tenerrima A. Peter)
Slender tufted annual 2 - 6 ins. high. Spikelets ovoid or cylindric, 3 - 6 mm long with purplish-green obtuse glumes. Style 2-fid. Nutlets smooth. Swampy places, seepage zones on rocky outcrops, etc.; sea level - 5,500 ft.
KENYA - Central Region and Nairobi.
TANGANYIKA - Widespread but uncommon.

10. E. caribaea (Rottb.) Blake. (Fig. 33)
(E. capitata R.Br.)
Stout annual 2 - 9 ins. high, but occasionally up to over 1 ft. Spikelet ovoid, 2.5 - 6 mm long with greenish-red obtuse glumes. Style 2-fid. Nutlets smooth. Among mangrove roots, in river deltas; sea level.
TANGANYIKA - Coast and Mafia Island.
ZANZIBAR - Pemba Island.

FUIRENA Rottb.

Fuirena is a small genus occurring in the warmer countries only. There are ten species recorded from East Africa and these occur in most moist habitats, seasonally flooded grasslands, pools, swamps and lake shores at all altitudes from sea level to about 7,000 ft.

Both annual and perennials are likely to be found. All are with nodose triangular leafy stems, and spikelets akin to Scirpus, in which a number of authors include the genus. The inflorescence is usually corymbose paniculate, but sometimes it is contracted. The spikelets have numerous spirally arranged glumes, but in a few species these are 5-ranked and the spikelets are angular in section. Usually the glumes are grey-green, pubescent, with a long terminal recurved bristle, but in some the bristles are straight or absent and the glumes more glabrous and brownish-green. Hypogynous bristles and scales are usually present, linear, and somewhat variable, even to being absent in the section Hemiscirpus (species 1 - 5). But in others, in the section Fuirena (species 6 - 10), the three inner ones have a broad, very characteristically shaped lamina. The style is 3-fid, linear, with an enlarged base which persists on the nutlet as in Bulbostylis, more rarely this is minute. The nutlets are trigonous, obovoid, with a smooth or transversely wrinkled surface, usually black at maturity but in a few species they are greenish.

Key to Species

1. Spikelets very large, up to 20 mm long and 6 mm wide..... ..... 5. F. pachyrrhiza
Spikelets not over 12 mm long and 5 mm wide 2

2. Perennials; leaves very wide, 10 - 30 mm 3
Annuals or perennials; leaves up to 9 mm wide 4

3. Sheaths and stems acutely angled ..... 10. F. umbellata
Sheaths and stems not angled ..... 9. F. calolepis

4. Glumes with a long bristle, usually recurved 5
Glumes with a short straight mucro 8

5. Annuals 6
Perennial ..... 4. F. pubescens

6. Glumes brown with a green keel excurrent into a straight bristle ..... 3. F. abnormalis
Glumes grey-green, often dark, bristles recurving 7

7. Spikelets 8 - 12 mm long and 3 - 4 mm wide ..... 6. F. ciliaris
   Spikelets 6 - 8 mm long; and 1.5 - 2.5 mm wide .....
   ..... 8. F. leptostachya

8. Spikelets angular, with 5-ranked glumes ..... 1. F. stricta
   Spikelets not angular, terete 9

9. Spikelets linear, 2 - 3 mm wide; perennial .... 2. F. chlorocarpa
   Spikelets 3 - 4 mm wide, ovate-elliptic; annual .....
   ..... 7. F. claviseta

1. F. stricta Steud. (Fig. 14)
Rhizomatous or tufted perennial, 6 - 15 ins. high with short linear leaves. Spikelets 12 mm long, 3 mm wide, in terminal and lateral clusters of 1 - 4. Glumes green or brown with a green keel. Hypogynous bristles linear. Nutlets brownish green at maturity. Only differs from F. chlorocarpa in the angled spikelets. Swamps; 2,500 - 6,500 ft.
KENYA - Western Region.
TANGANYIKA - Southern Highlands Region.
UGANDA - Western Province and Buganda.

2. F. chlorocarpa Ridl.
Stoloniferous perennial 12 - 18 ins. high with short linear leaves. Inflorescence of terminal and lateral clusters of 2 - 4 spikelets with acute grey-green glumes. Nutlets similar to F.stricta but greener. Damp and swampy places; 3,000 - 7,000 ft.
KENYA - Widespread but not common.
TANGANYIKA - Northern, Western and Southern Highland Regions.

3. F. abnormalis C.B.Cl. (Fig. 20)
Leafy annual up to 1½ ft high. Inflorescence corymbose, with 2 or more lateral corymbs at each node. Spikelets 4 - 7 mm long with glabrous light brown glumes. Hypogynous bristles absent. Nutlets smooth or faintly wavy. Pools, ditches and swamps; 3,000 - 6,000 ft.
TANGANYIKA - Southern Highlands and Southern Region.

4. F. pubescens Kunth
Rhizomatous perennial up to 2½ ft high. Spikelets broadly ellipsoid, 6 - 10 mm long in corymbose clusters or panicles. Glumes grey-green with a recurved mucro. Bristles absent. Nutlets small, smooth. Swamps and swampy places; sea level - 7,000 ft.
KENYA - Widespread and fairly common.
TANGANYIKA - Lake, Northern and Central Regions.
UGANDA - Western Province and Buganda.
ZANZIBAR - Zanzibar Island.

5. F. pachyrrhiza Ridl.
Rhizomatous perennial 1 - 3 ft high. Spikelets up to 20 mm long with long-mucronate grey-green glumes 3 - 4 mm long. Bristles absent. Nutlets small, smooth. Lake shores and swampy places; 3,000 - 5,000 ft.
KENYA - Western, Rift Valley, North-eastern Regions and Nairobi.
TANGANYIKA - Widespread except in the extreme south.
UGANDA - Eastern Province.

6. F. ciliaris (L.) Roxb. (Fig. 5)
(F. glomerata Lam.)
Hairy annual 4 - 18 ins. high. Panicle oblong with a few close clusters of dark green or brown spikelets 8 - 12 mm long, 3 - 4 mm wide.

Glumes with a long mucro. Hypogynous scales as long as the nutlet, the inner 3 with a broad blade on a long claw. Nutlets smooth. Swampy places, stream banks and pools; sea level - 5,000 ft.
KENYA - Central Region and the Coast.
TANGANYIKA - Widespread.

var. angolensis Schinz
This is scarcely distinguishable from the above except by the crescent-shaped blade of the hypogynous scale. Swampy places and pools; 3,000 - 4,000 ft.
TANGANYIKA - Lake and Central Regions.

7. F. claviseta A. Peter (Fig. 8)
Annual 6 - 18 ins. high closely resembling F. ciliaris except for the emucronate glumes and the swollen, veinless, tailed lamina of the inner clawed hypogynous scales. Damp places; sea level.
ZANZIBAR - Zanzibar Island.

Some gatherings of this species have been named F. seriata C.B.Cl., but this appears to be a synonym of F. umbellata. I have used the only name of which I am aware that is correctly applied to this species, though this may not prove to be the earliest name available.

8. F. leptostachya Oliv. (Fig. 4)
Tufted hairy annual 6 - 18 ins. high, differing from F. ciliaris in the slighter habit, the smaller spikelets and hypogynous scales with a crescent-shaped, not squarish, lamina. Swamps and lake shores; 1,500 - 5,500 ft.
KENYA - Widespread, locally abundant.
TANGANYIKA - Widespread.
UGANDA - Buganda.

9. F. calolepis K. Schum. (Figs. 7, 21)
(F. cinerascens Boj. ex C.B.Cl.)
Pubescent perennial up to 18 ins. high with a stout creeping rhizome. Inflorescence dense, with numerous 6 - 12 mm long, grey-green spikelets. Inner hypogynous scales as long as the nutlet with a crested laterally winged blade and a ciliate claw. Nutlets smooth. Damp places; sea level - 500 ft.
KENYA - Coast.
TANGANYIKA - Coast.
ZANZIBAR - Zanzibar and Pemba Islands.

10. F.umbellata Rottb. (Fig. 15)
(F. multiflora A. Peter, F. appendiculata A. Peter)
Stout perennial up to 5 ft high. Panicle large with numerous 6 - 10 mm long spikelets in dense umbels. Glumes green or brownish with a recurved bristle. Inner hypogynous scales laminate, similar to F. ciliaris but lacking the long claw. Nutlets smooth. Swamps, stream banks and pools; sea level - 4,000 ft.
KENYA - Western Region and the Coast.
TANGANYIKA - Widespread, including Mafia Island.
UGANDA - Eastern Province and Buganda.
ZANZIBAR - Zanzibar Island.

LIPOCARPHA R. Br.

Lipocarpha is a small genus of under 20 species which occur in the warmer parts of both hemispheres. Only 4 have been recorded in tropical east Africa where they can be found over a wide range of altitude in seasonally flooded grassland, swamps and river beds and, more rarely, in seepage zones on rocky outcrops.

The habit is varied. Slender annuals and stout tufted perennials occur but all have glabrous basal leaves and nodeless stems. The inflorescence is a solitary terminal head with several leafy bracts, sometimes, as in Scirpus, reduced to a solitary pseudolateral spikelet with a single erect bract. The spikelets have numerous closely packed spirally arranged glumes of which the lowest 2 are empty, the succeeding ones are bisexual (having nutlets) and deciduous in fruit, leaving the naked rhachilla, and the uppermost male or sterile. Within the glumes there are 2 elliptic or obovate scales surrounding the nutlet. The nature of these is obscure and has given rise to several differing theories but the most acceptable, considering the other resemblances to Scirpus, is that these scales have originated in the fusion of the hypogynous scales. The style is small, 3-fid or 2-fid without a swollen and persistent base. The nutlets are more or less trigonous or biconvex, obovoid or oblong, and smooth.

Key to Species

1. Glumes acuminate, or with a long recurved awn; spikelets solitary or several in a dense head 2
   Glumes obtuse; spikelets several in a dense head ..... 1. L. chinensis

2. Spikelets solitary ..... 4. L. monostachya
   Spikelets several in a dense head 3

3. Stoloniferous perennial ½ - 2 ft high ..... 2. L. albiceps
   Slender annual 3 - 12 ins. high ..... 3. L. pulcherrima

1. L. chinensis (Osb.) Kern (Fig. 51)
   (L. senegalensis (Lam.) Th. & Hel. Dur., L. argentea (Vahl) R.Br.)
   Tufted perennial 1 - 2½ ft high with leaves in a basal tuft. Heads white, 15 - 25 mm diam. of 2 - several spikelets with 1 - 2 spreading basal bracts. Swamps, river banks; sea level - 6,000 ft.
KENYA - Western, Rift Valley and Central Provinces.
TANGANYIKA - Widespread.
UGANDA - Eastern Province, Buganda and the Sese Islands.
ZANZIBAR - Zanzibar Island.

2. L. albiceps Ridl.
   Rhizomatous perennial 1 - 2 ft high with terete stems. Heads 10 - 20 mm diam. of 3 dense spikelets with 2 - 3 short spreading bracts. Glumes dark red below, white above. River banks, swamps, damp places; 3,000 - 4,000 ft.
TANGANYIKA - Western Region.
UGANDA - Western Province.

3. L. pulcherrima Ridl.
Slender annual 4 - 10 ins. high with a terminal head of 3 spikelets. Spikelets 3.5 - 4.5 mm long with blackish red glumes with a conspicuous recurved green mucro. Seepage zones on rocks, swampy grassland, swamps; 1,000 - 8,000 ft.
KENYA - Nairobi.
TANGANYIKA - Lake, Northern, Tanga and Western Provinces.
UGANDA - Buganda.

4. L. monostachya R. Gross & Mattf.
Slender annual 2 - 4 ins. high with few fine leaves. Spikelets 4 mm long with dark red glumes with a long recurved mucro. Seasonally wet places; 1,500 - 4,000 ft.
TANGANYIKA - Western, Central and Southern Regions.

Of similar habit to Scirpus isolepis but differing in the long mucronate glumes.

(Received 5th. October 1964)

Explanation of Figures

PLATE I

Fig. 1. Bulbostylis holotricha - x 1
Fig. 2. Bulbostylis humilis - x 1
Fig. 3. Bulbostylis glaberrima - x 1
Fig. 4. Fuirena leptostachya - x 25
Fig. 5. Fuirena ciliaris - x 25
Fig. 6. Bulbostylis buchananii - x 1
Figs. 7,21. Fuirena calolepis - 7,x 20; 21,x 1
Fig. 8. Fuirena claviseta - x 20
Fig. 9. Bulbostylis densa - x 1
Figs.10,11,18. Bulbostylis boeckeleriana - 10,x 15; 11,x 15; 18,x 1
Fig. 12. Ficinia filiformis - x 15
Fig. 13. Ficinia gracilis - x ½
Fig. 14. Fuirena stricta - x 1
Fig. 15. Fuirena umbellata - x 20
Fig. 16. Bulbostylis schimperiana - x 15
Fig. 17. Bulbostylis atrosanguinea - x 15
Fig. 19. Bulbostylis aphyllanthoides - x 1
Fig. 20. Fuirena abnormalis - x 1

PLATE II

Fig. 22. Fimbristylis longiculmis - x 10
Figs.23,39. Fimbristylis exilis - 23,x 10; 39,x 1
Fig. 24. Fimbristylis madagascariensis - x 10
Fig. 25. Fimbristylis miliacea - x 1½
Fig. 26. Eleocharis dulcis - x 5
Fig. 27. Eleocharis complanata - x 1½
Fig. 28. Fimbristylis dichotoma - x 10
Figs.29,32,41. Eleocharis acutangula - x 5
Fig. 30. Fimbristylis obtusifolia - x 1
Fig. 31. Fimbristylis oligostachys - x 1½
Fig. 33. Eleocharis caribaea - x 1½
Fig. 34. Fimbristylis humilis - x 1½
Figs.35,36. Fimbristylis squarrosa - 35,x 1½; 36,x 15
Fig. 37. Eleocharis atropurpurea - x 2
Fig. 38. Fimbristylis complanata - x 1
Fig. 40. Fimbristylis monostachya - x 1½

PLATE III

Fig. 42. Lipocarpha monocephala - x 1½
Fig. 43. Scirpus maritimus - x 6
Figs.44,55. Scirpus cubensis - 44,x 6; 55,x 1
Figs.45,47. Scirpus costatus - 45,x 1; 47,x 15
Fig. 46. Scirpus setaceus - x 1½
Fig. 48. Scirpus confusus - x 15
Fig. 49. Scirpus roylei - x 1
Fig. 50. Scirpus praelongatus - x 1
Fig. 51. Lipocarpha chinensis - x 1½
Fig. 52. Scirpus isolepis - x 1½
Fig. 53. Scirpus steudneri - x 1
Fig. 54. Scirpus inclinatus - x 1
Fig. 56. Scirpus mucronatus - x 1

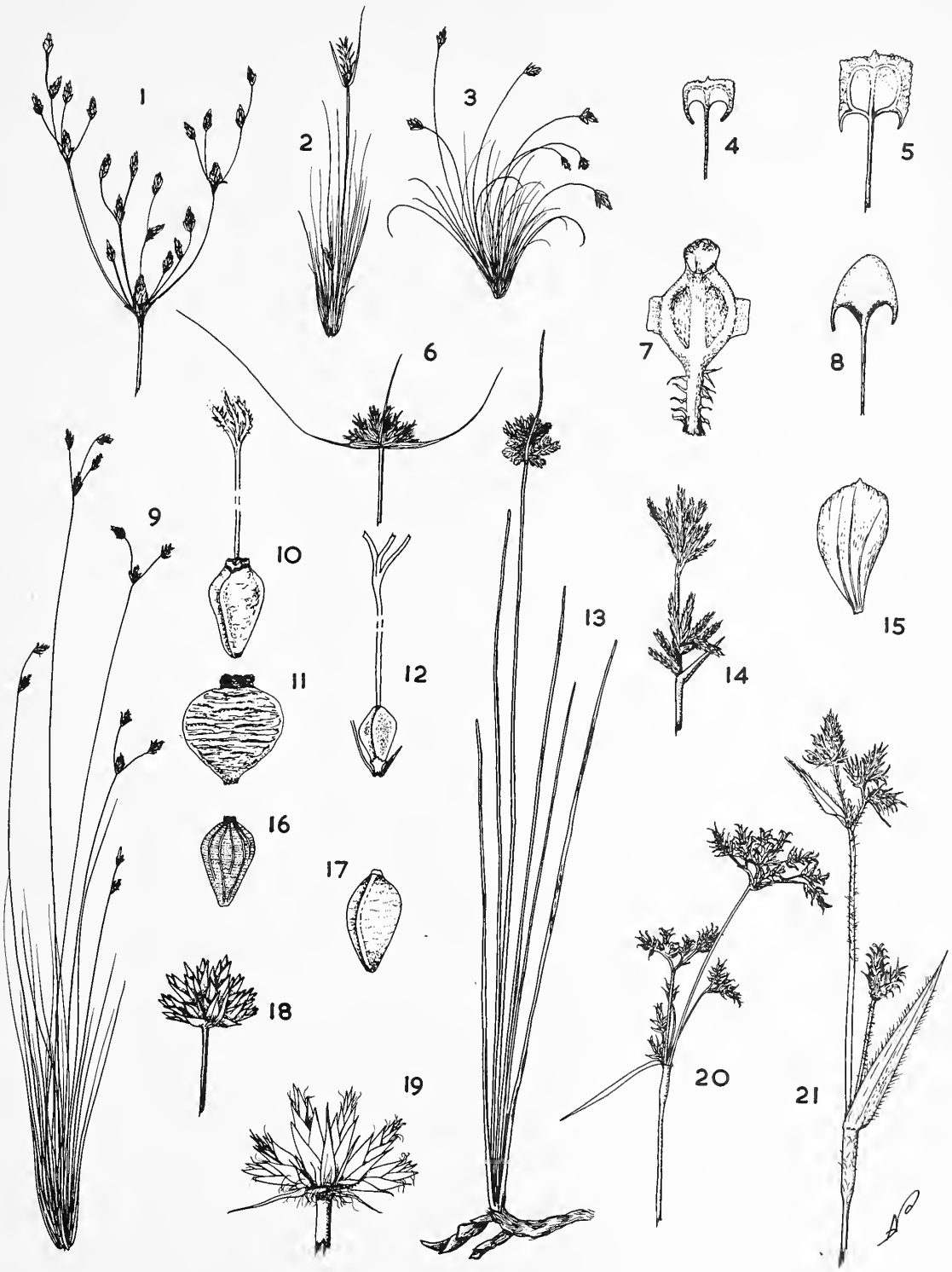

PLATE I


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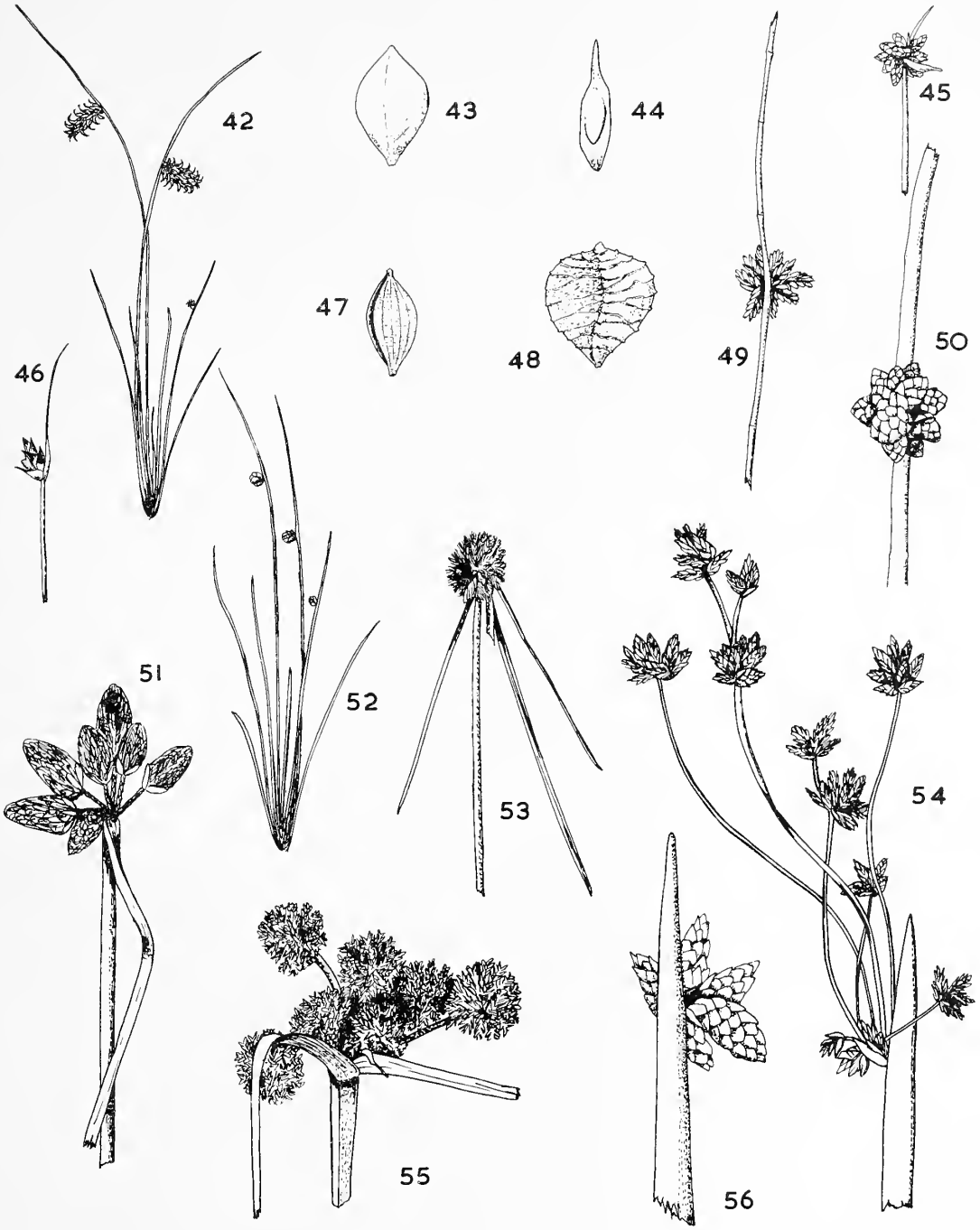


PLATE III

NOTES ON THE BIOLOGY OF THE CARPET VIPER, ECHIS CARINATUS PYRAMIDUM (Geoffroy), IN THE NORTHERN FRONTIER PROVINCE OF KENYA

By

A. DUFF-MACKAY

Introduction

The work owes its origin to an undertaking by Mr. J.H.E. Leakey and the author to collect the venom of carpet vipers for use in the production of antivenom. It was intended not only to collect venom but also to make a study of the biology of the vipers. The work is incomplete as the whole operation was plagued by numerous unavoidable hitches, but, as a study of the large amount of data collected has revealed some interesting points, and as it is unlikely that the work will ever be continued on the same scale, it has been considered desirable to publish a note outlining the results.

Camp was set up at Moille Hill, 10 miles north of Merille on the Isiolo - Marsabit road, and it was there that the captive snakes were kept and "milked" of their venom. A team of 8 Turkana snake collectors was employed and operated over an area of approximately 250 square miles extending, on either side of the main road, from Laisamis in the north almost to the Serolevi River in the south.

During the periods from the 27th October to the 11th December, 1962 and from the 7th January to the 13th March, 1963 a total of 6,933 carpet vipers were collected, measured, and recorded, together with data on weather conditions and locality. Precise measurements of rainfall, temperature and humidity were taken at the camp, but as collecting was often as far away as 20 miles, particularly in the latter half of the operation, this was of little value, so in these places signs of recent rain etc. were noted. These data have been fully investigated in an attempt to find out how these semi-desert reptiles are affected by rainfall.

The captives were kept in two pens of fine wire netting 30 ft in diameter. There were never more than 3,000 at a time as they began to show signs of starvation after a few weeks and were released while they were considered to have a good chance of surviving. They were all marked and not a single one was taken a second time. Much time was spent observing the behaviour of snakes in pens and this related to observations in the field.

It is a matter of considerable annoyance, that, due to the prevailing security situation in the area, the author is unable to return to Moille to obtain photographs badly needed for this paper, and to check on a number of points which have emerged only since the data have been exhaustively examined.

The Habitat

Where collecting was most successful there was scattered bush with very little grass cover on sandy soil; here the few large Acacia trees provided logs which were favoured by the snakes. Usually only the large heavy logs, well rotted and eaten by termites underneath, harboured carpet vipers. It was under such logs too, that skinks and geckos, scorpions, solifugids and centipedes, were to be found.

On numerous occasions apparently suitable logs were investigated where there was thick grass cover and no open ground; the results were invariably disappointing. A whole morning was spent in turning over enormous logs with the help of a Land-Rover on the banks of the Merille River where there was thick vegetation without taking a single specimen, yet a short distance away where there was open ground carpet vipers were found to be abundant under similar logs. It may be, and this seemed unlikely, that in such places they spend the day under tufts of grass and brushwood etc. and that this was in such abundance that they were difficult to find. On the other hand they may avoid thick cover as a direct result of their feeding behaviour. (This will be discussed later).

Numerous tracks of carpet vipers were to be seen on the ground in places where the sand was soft, many of these leading to and from rodent holes. This was true where there were good logs and where there were none as in the Kaisut Desert, and as the number of tracks that could be seen every day even in the heavily collected area around camp did not noticeably diminish throughout the period, it appears that the majority of the population, particularly the adults, spent the day in such holes.

The Population

The total length of each specimen collected was measured in centimetres; the smallest was 13 cm (one specimen), and the largest 69 cm (one specimen). They were considered to become adult at about 40 cm, all those smaller than this being juveniles and sub-adults.

The number of juveniles taken (under logs) outnumbered the adults by 10.7 to 1, which can hardly be a true value of their proportion of the population. There were 16 snakes caught out at night of which 1 was juvenile and 15 adult. Plotting the length against the number of specimens taken, graphs were drawn of the total catch in each week of collecting (16 in all), and this showed clearly one large peak of juveniles of which the mean value for size got progressively larger from the beginning to the end of the collecting period. This is illustrated in Fig. 1 with four graphs of approximately 2 weeks collecting separated by a period of 4 weeks. The small peak at about 18 cm in (d) is a new batch of young which will be investigated later.

Of each of the 16 graphs of one week of collecting the mean value for length in the main peak was taken and plotted as a graph covering 19 weeks (there was no collecting in week 8, 9, or 10) - Fig. 3 (a). It is important to note that although this clearly indicates that the snakes in the main peak are of about the same age, Fig. 3 (a) is not a growth curve. Firstly because in each week there were always some snakes in the 15 to 20 cm range showing that there were young being born all the time, which, merging with the main peak would hold it back,

and, secondly, from the proportion of small to large snakes collected it is apparent that, at any rate in the region of 25 to 40 cm the larger the snake the smaller the possibility that it will be taken by the collecting methods here employed, which would also hold back the progression of the main peak. A growth curve would, therefore, be considerably steeper than that in Fig. 3 (a), but it is unfortunately impossible to calculate a reasonably accurate factor for its correction.

The Effect of Rainfall

The position of the main peak of juveniles from week to week shown in Fig. 3 (a) shows some definite groupings of points above and below the curve drawn through them. This has been investigated from the point of view of lunar periodicity, differences of collecting area, humidity and rainfall. Only the latter two show any correlation at all. Fig. 3 (b) shows a graph of the average saturation deficit for each week taken with a wet and dry bulb hygrometer at 9.00 a.m. at the camp, (note that, as mentioned before, the collecting area grew further away from the camp as the operation proceeded until it was usually 15 to 20 miles distant). The thick horizontal lines at the bottom of Fig. 3 (a) indicate periods in which recent rainfall was noted as having occurred in the collecting area - generally an effort was made to go collecting where there had been rain.

A comparison of Figs. 3 (a) and (b) shows that the larger juveniles were more inclined to stay under logs when the ground was damp, and there was a lower saturation deficit, than during the dry periods.

Two peaks of births were found in the collection of the week of the 3rd to the 9th February, 1963, during which there was a good shower of rain (about the 7th and 8th), Fig. 2(b). Before this there was the usual small birth rate, Fig. 2 (a). These two peaks can be followed in the following four weeks - Fig. 2 (c), (d), (e) and (f) after which collecting ceased.

The positions of these two peaks in Fig. 2 are plotted in Fig. 4, and it will be seen that not only do they first appear in a different position but they progress very differently. The two peaks can not be separated by locality of collection as all in Fig. 2 were collected in the same area. Peak y appears to have arrived a little before x but not to the extent that would separate it so far, nor explain the very different curves in Fig. 4. It can only be supposed that the two curves consist of individuals of different sex and that the unlikely curve formed by x is due to it being held back in its progression by the continual small numer of births from which y has apparently managed to escape; notice, for instance, how the small peak z in Fig. 2 (e) (following another shower of rain) has merged into x in Fig.2 (f).

The curve of y in Fig. 4 looks like a true growth curve. If it is, and if the error in the curve formed by the position of the main peak (Fig. 3 (a)) be taken as small at its lower point, then these two curves may be joined together showing that the individuals in the main peak were born about 5 weeks previous to the first week of collecting, that is, towards the end of September 1962. The collecting area was very dry when first seen on the 24th of October and it was impossible to find out whether there had been any rain in the previous few weeks, certainly there was not much as there was no new green vegetation. According to the local herdsmen the rain was expected at the beginning

of October and they were migrating south to better grazing where there had been rain (more than 30 miles south). The first trace of rain in the collecting area came on the 27th October and there was little more until the 25th of November.

Fig. 3 (c) is a graph showing the proportion of newly born snakes each week, that is, those under 20 cm in length. There was no time when there were absolutely no births, however, there is a steady decline in the birth rate from the 3rd to the 7th week. When collecting was resumed in the 11th week the birth rate had returned to about its former level. This, together with Fig. 2 indicates a correlation between births and rainfall, the young being born mainly when the ground becomes wet. From this it follows, also, that the female snake must be able to delay giving birth for a few weeks while weather conditions are unsuitable for the young.

Among the captives there were three batches of eggs laid, one batch of 5 eggs in December 1962 and another two of 5 and 6 eggs in February 1963. The eggs contained no embryos and had perfect tough white shells, and as it was hard to imagine that these were immature or sterile, it was assumed that the snakes were oviparous. Furthermore, there were no births in the pens and such would certainly have been noticed as very small snakes were not put in the pens but were put aside in a box to be released when it was convenient. Here the author is indebted to Mr. C.J.P. Ionides and Captain Charles Pitman for expressing strong doubts that they are oviparous, and in particular to Captain Pitman for making extensive enquiries from which he was able to confirm that carpet vipers are definitely known to be ovo-viviparous. (See Wall, F. "The Snakes of Ceylon" 1921.) While assuming oviparity there are some awkward questions to be answered regarding the rate of emergence of the young.

Activity and Water Relations

The captive snakes became active towards sunset and were continually on the move until sunrise the next morning. On no occasion was a carpet viper seen in the open in the wild during the day, only one specimen was found emerging from a hole and that was at 6.00 p.m.

The rate of activity of the captives in the pens was certainly very high, and if they did not feed, and most did not, they became very thin after about four weeks. This of course, is not truly indicative of what happens in the wild state as the captives are bound to have been affected by overcrowding. However, there is some evidence of similar high activity in the wild and this is from the venom. Newly caught snakes were always milked of their venom before being put in the pens, they were milked again exactly one week later and this second milking always produced at least another half as much venom and this of a marked darker orange-yellow colour, indicating a high rate of venom discharge and a high rate of venom synthesis, i.e. in one week forcibly emptied venom glands became more heavily charged than they normally have a chance to in the wild.

After a week or two in the pens the snakes' skins became hard and wrinkled and those that were due to slough were unable to do so. As this was obviously due to the skin drying out, shallow ditches were dug on the side of each pen and covered with Papyrus grass matting and this was watered occasionally to keep the soil damp. It was hoped that the

snakes would take to spending the day under these mats, but this was not to be so, very few were found under the mats and these only on the tops of ridges between the troughs where their backs could be in contact with the matting, the remainder lying out in the open as usual in large tangled heaps of 40 to 100 individuals. After this failure every single snake was collected and "put to bed" in the new quarters, a long and tiresome job but with pleasing results as in a few days hundreds of new sloughs were to be found in the pens, some of them of two layers thick. Thereafter the skins remained in healthy condition.

Due to the severe effect of desiccation it would be misleading to draw conclusions as to the frequency of sloughing from the captives. Very few sloughs were seen in the field.

It is, then, of great importance that carpet vipers should spend the day in a microclimate of high humidity. As to how they choose suitable places is not at all clear and is presumably tied up in complexities of the general pattern of behaviour rather than a simple search for suitable conditions with the help of humidity receptors. Temperature may be an important guide as suitable retreats would be expected to have a higher temperature than that of the ground surface in the early morning, but then this does not explain why larger snakes are to be found under logs when the ground is damp. (Fig. 3).

The explanation for the proportionately small numbers of adults collected probably lies here. Nearly all the snakes taken were under logs and it seems reasonable that if a log had a hole beneath it that was big enough to take a large carpet viper then it would be dry. Most of the large snakes taken were probably the few that were caught out without a more suitable retreat. There would be no harm in spending the odd day under unsuitable logs and this they certainly did as a lot, of all sizes, (though small overall proportion) were found under dry, newly turned, logs.

The captives drank frequently from the troughs of water provided.

Feeding

From observations of faeces and regurgitated food the following were found to be included in the diet:-

Vertebrates:- Rodents, lizards.
Arthropods:- Solifugids, scorpions, centipedes.

One small specimen was taken in the early evening while swallowing a small frog.

Termites were often found in the faeces and occasionally small beetle and grasshopper remains, but all these could be put down to having been first eaten by the lizards which were subsequently eaten by snakes. During an enormous emergence of insects after the rain on the 27th October 1962 a lamp was hung over the pens at night and a few snakes were later found to have eaten beetles. Large tenebrionid beetles were always present beneath the mats but these were apparently never taken.

Dead scorpions, solifugids and centipedes were readily taken as also were dead lizards and mice. Spiny mice (Acomys sp.) which were

common in the area were, however, never eaten when left dead in the pens. When Acomys was first dismembered most of those parts with no spines were eaten but parts armed with spines were never eaten although these were often found to have been dragged far away from where they were originally put.

An attempt was made to feed the snakes on pieces of plain meat. The first piece of goat's meat which was put in the pen was immediately smelt by several snakes near it, and one, after quickly "licking it over", swallowed it. Many more pieces of meat were put in after this and on numerous subsequent occasions, mutton, beef and goat's meat were tried but not a single piece was ever eaten. It was intended to try flavouring pieces of meat with extracts of the normal food, but this experiment, like so many others, regretably never materialised.

Cannibalism was rife. It was seldom that the pens were visited at night without seeing at least one snake with its head gripped in another's mouth. The pair would remain motionless like this for several minutes then the one which had been caught would wriggle violently and then so would the attacker and the pair would skip across the pen in a most ridiculous fashion. The bite appeared to have no effect on the victim and this is probably why comparitively few were swallowed - the attacker waiting in vain for the victim to die. Carpet vipers were never seen to be bitten by their fellows anywhere but on the head.

The head biting was a great nuisance when it came to collecting venom as the venom glands were frequently punctured resulting in internal bleeding and mixing of blood with the venom stored in the glands. It was, however, useful as it enabled the method of attack to be observed on numerous occasions, and as the ground surface had, in places, become soft and powdery, distinct tracks were left which could be used to interpret similar tracks in the field.

The carpet viper is well known for the way in which it draws its body into loops and produces a continuous stridulation by rubbing the lateral scales, the keels of which are serrated, of one part of the body against another, the undulations moving from front to back and new loops being formed some way from the head so that the head can remain still in the same position all the time. Carpet vipers are very vicious and frequently attack for defence, the method of progression being to spring forward from the looped position, draw up the hind part of the body into stridulating loops again and spring forward again and so on. In this way they move at an alarming rate. The method of attacking each other in the pens was very similar only less time was wasted in forming close loops and there was no stridulating. This is a very efficient method of progression on flat ground and although it could probably never rival an accomplished sidewinder in speed is almost certainly far more effective on hard sand which is predominant in, at any rate, the habitat in which the population here under discussion was found. It is also a movement very suitable for chasing after and capturing an animal as at every few inches the body is drawn up into a striking position. In passing, this method of progression can be seen in crude form in many other snakes when striking repeatedly from a looped "stance" and its development to perfection in carpet vipers may have lead to the evolution of the stridulatory behaviour.

This mode of progression left very distinct tracks in the soft sand and these were frequently observed in the field. There would be

the normal single line tracks made by slow crawling on the ventral scales, then this would break off into the "attack movement" track for a short distance seldom exceeding 3 feet and leading off in any direction, then the single line track was resumed. This indicates that an important way of feeding is to move slowly over open ground and, on sighting suitable prey, make a short fast rush after it. If this is the main method of hunting then it explains why so few carpet vipers were found where there was not a lot of open ground. Unfortunately tracks of the prey were never seen in this connection because the sand was either too coarse to take small tracks, or if fine enough they would have been obliterated by the strong wind that always arose shortly before daybreak. The prey was certainly available in these places, geckos and solifugids in particular were often seen on open ground at night.

Tracks leading to and from rodent holes made in the same night were also frequently seen, so it may be that they visit these holes in the hope of finding the rodents at home, or any other animals taking refuge therein.

Enemies

The impression was gained that the carpet vipers had few natural enemies. The population was very large, the number of young produced small (batches of eggs laid numbered 5 or 6, and Colonel Wall states that there are from 3 to 15 in a brood) and, though nocturnal, they appear to take no pains to keep to cover, moving over flat open ground even on bright moonlit nights.

One evening a red cobra (Naja nigricollis pallida Boulenger) was seen and captured in one of the pens. In all two cobras were caught and one seen out at night, a fourth being discovered beneath a log in the daytime. Cobras are well known snake eaters and it is unlikely that they do not eat carpet vipers and, in fact, are very likely to be the carpet vipers main enemy.

A dead shrike was found near the pens one morning with haemorrhage in one leg and half the underside of the body. It had obviously tried to capture one of the carpet vipers lying out in the open.

Carpet vipers are extremely vicious natured and will rasp their scales and strike out in an impressive threat display at the smallest provocation. Presumably potential enemies are very wary of them, and this is supported by the fact that the egg-eaters (Dasypeltis) in the area very closely mimic them. The mimicry of colour and body pattern is so good that it is difficult to distinguish the two on pattern alone. (See photograph). By examining a series in the Coryndon Museum it has been found that the serrations on the lateral scales of these mimics are generally much more pronounced than they are on non mimic Dasypeltis in the southern part of Kenya. (Fig. 5).

The Venom

Venom extracted from newly caught snakes of about 30 cm and under dried to pale yellow, almost colourless, flakes. That of snakes of over 45 cm was a deep orange-yellow colour. After being in the pens a week they not only produced much more venom but it was a darker colour in both small and large snakes.

There were three cases pf snake-bite from carpet vipers among the collectors, one from a large specimen and two from small, and in all cases there was only one fang puncture. These were treated with specific antivenom and no serious symptoms developed. The author was bitten on three occasions by small snakes, also one fang puncture from each. The first was treated by cutting and applying rubber suction cups and the other two were neglected; only very local swelling and slight local discomfort was experienced in each case.

A sand boa, Eryx colubrinus loveridgei Stull, which was kept in one of the pens was found with a large swelling consisting of fluid lodged under the skin, it having presumably been bitten by a carpet viper. About a week later it was found again in healthy condition with no swelling and the skin in the region of the bite dry and hard.

The venom was collected in shallow watch glasses in a specially constructed apparatus, and as milking was done almost every day scraping out of dried venom also had to be done frequently. On two occasions (3 weeks after the first snake-bite) the author had great difficulty in performing this task due to severe smarting of the eyes and almost incessant sneezing. This was taken to be due to hypersensitivity acquired as a result of frequent exposure to venom dust. The day following the second experience a minute cut about 3 mm long was made in the skin of the upper forearm just deep enough to bleed slightly and a minute drop of fresh venom introduced into it. The effect was startling as the entrance and incredibly fast spread of venom could be clearly felt. Within 20 minutes the entire fore and upper arm felt distinctly but mildly bruised. There was no swelling, no enlargement of the lymph nodes and no general illness, and in 24 hours the strange bruised feeling of the arm had completely disappeared.

After a lapse of 48 hours the experiment was repeated with a slightly larger drop of venom and it was planned to measure accurately the rate of spread; however, there was no noticable effect whatsoever. At this stage it was found also, that scraping of dried venom could be performed without any trouble. After this cutting and introducing venom was done regularly every 4 or 5 days, the dose being increased from the start to a fairly large drop held in a deeper cut about ½ cm long for a minute or two with the forefinger. The effects were always mild, there being slight swelling of an inch in diameter accompanied by the bruised feeling; also, a small area immediately around the cut turned a dark brown colour. This was noticed also in the two bites that were not cut and bled.

If, as the author believes, this was a true case of hypersensitivity, the method of desensitising can be recommended to workers with snake venom as being painless, very effective, and requiring the minimum of time and apparatus.

Weight for weight carpet viper venom is very toxic and, due to their vicious nature, the snakes have a well deserved reputation of being dangerous. Local Rendille herdsmen who frequently came to view the snakes in the pens were often questioned on the subject. Apparently snake-bite from carpet vipers was not uncommon but, surprisingly, none of them knew of anyone who had died or even suffered permanent effects as a result of such a bite. Their method of cure was essentially to cut the wound open to cause bleeding and to feed the victim on burnt milk and goat's hide for 3 or 4 days as an emetic. Perhaps these

people owe their survival to the fact that it has, apparently, never occurred to them that it is a good idea to hold the venom in, and cut off the blood supply to the affected tissues by application of a ligature.

Acknowledgment

I am particularly indebted to Mr. and Mrs. J.H.E. Leakey for their invaluable help and cooperation in the field, and for doing much of the recording at the camp. My sincere thanks are also due to Captain C.R.S. Pitman for reading and criticising the manuscript, and to the staff of the Coryndon Museum for their help and encouragement.

(Received 15th October, 1964)

Post Script

Since going to press I have received a communication from Captain Pitman stating that recent, as yet unpublished work has shown that, whereas Indian Echis carinatus are ovo-viviparous, E. carinatus from Eritrea have been found to lay fertile eggs. Although there is no confirmation, it now seems even more probable that I was correct in my original belief that the population around Merille is truly oviparous.

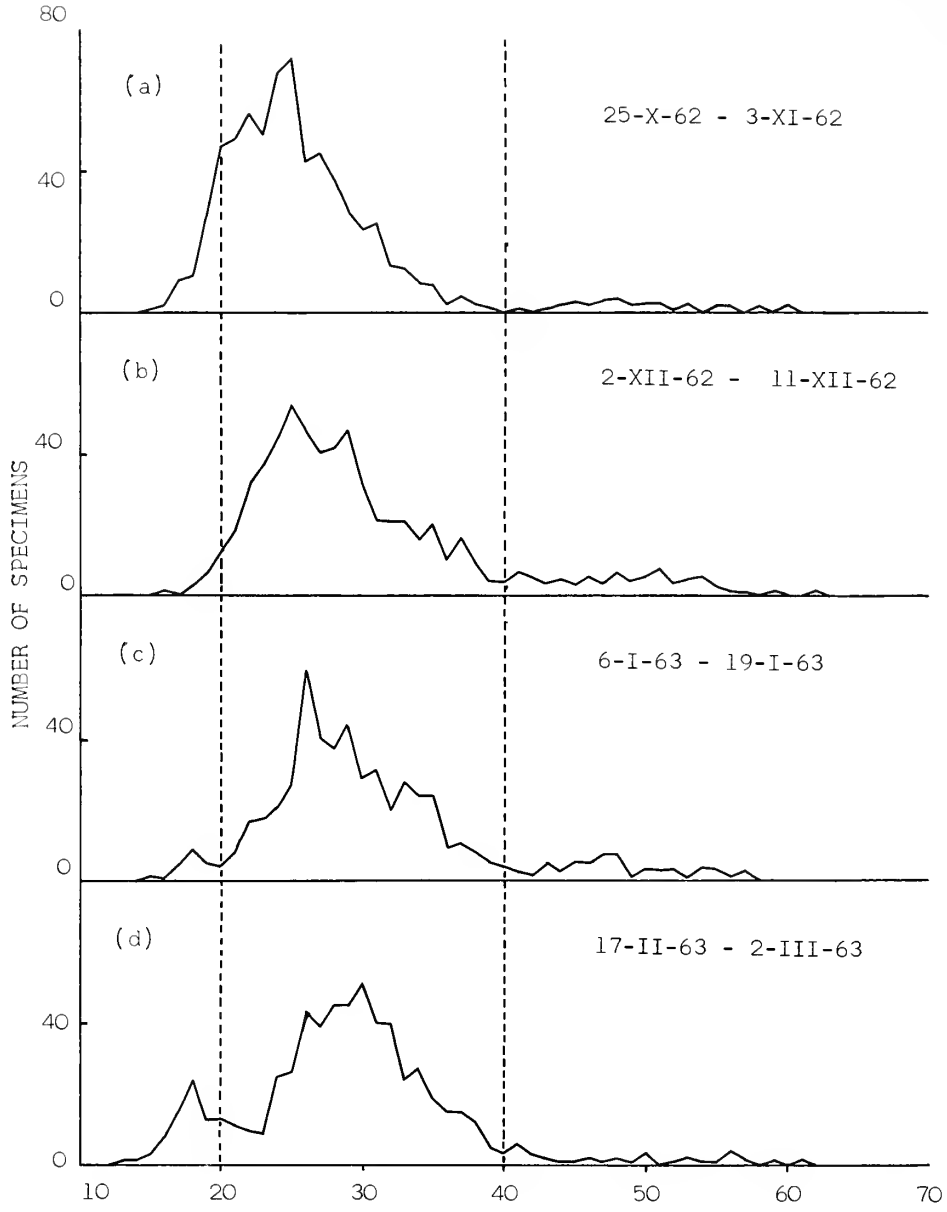

80
40
0
(a)
25-X-62 - 3-XI-62
(b)
2-XII-62 - 11-XII-62
(c)
6-I-63 - 19-I-63
(d)
17-II-63 - 2-III-63
NUMBER OF SPECIMENS
10
20
30
40
50
60
70
Total length in cms.

Fig. 1

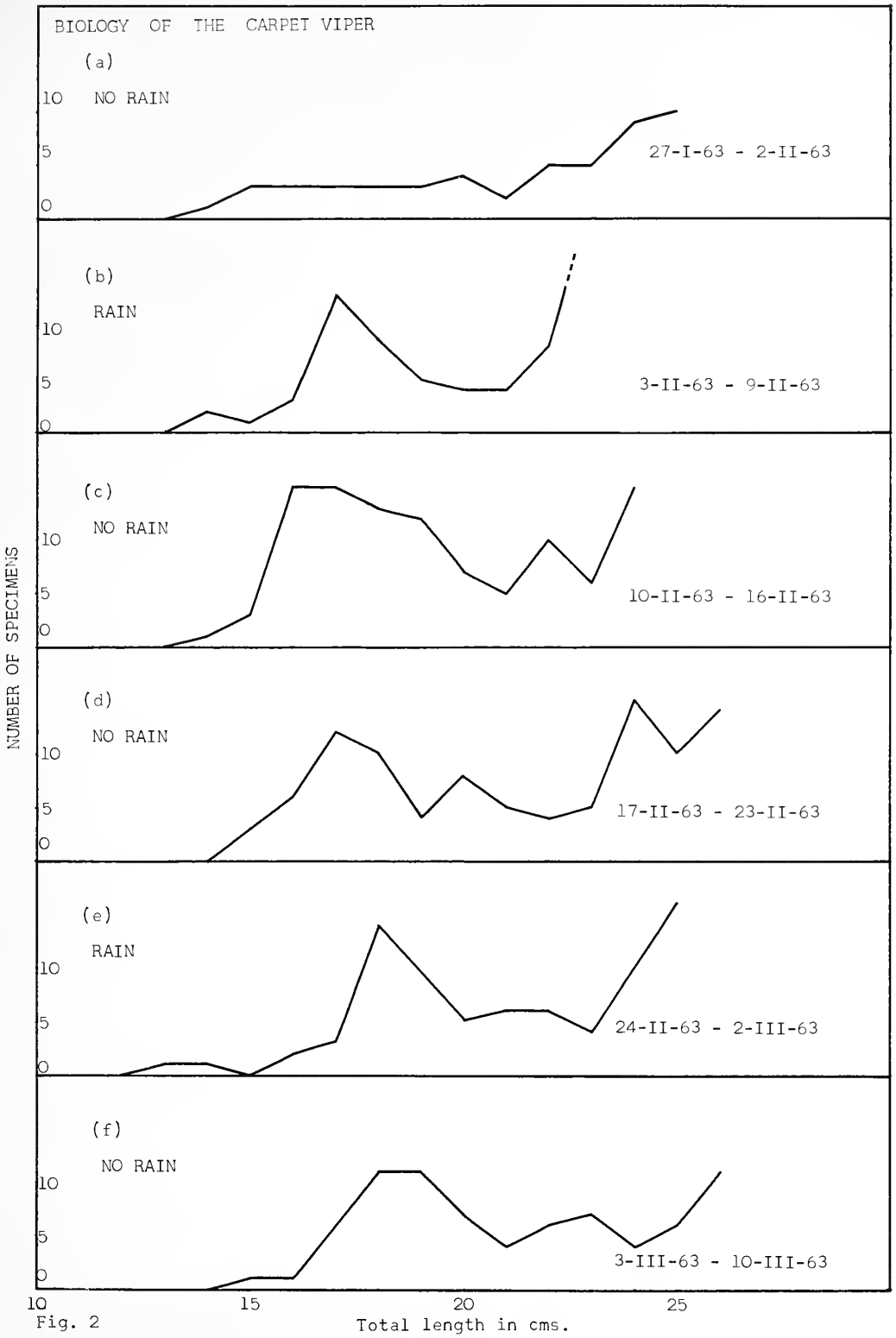

BIOLOGY OF THE CARPET VIPER
(a)
NO RAIN
10
5
0
27-I-63 - 2-II-63
(b)
RAIN
10
5
0
3-II-63 - 9-II-63
(c)
NO RAIN
10
5
0
10-II-63 - 16-II-63
(d)
NO RAIN
10
5
0
17-II-63 - 23-II-63
(e)
RAIN
10
5
0
24-II-63 - 2-III-63
(f)
NO RAIN
10
5
0
3-III-63 - 10-III-63
NUMBER OF SPECIMENS
10
15
20
25
Total length in cms.

Fig. 2

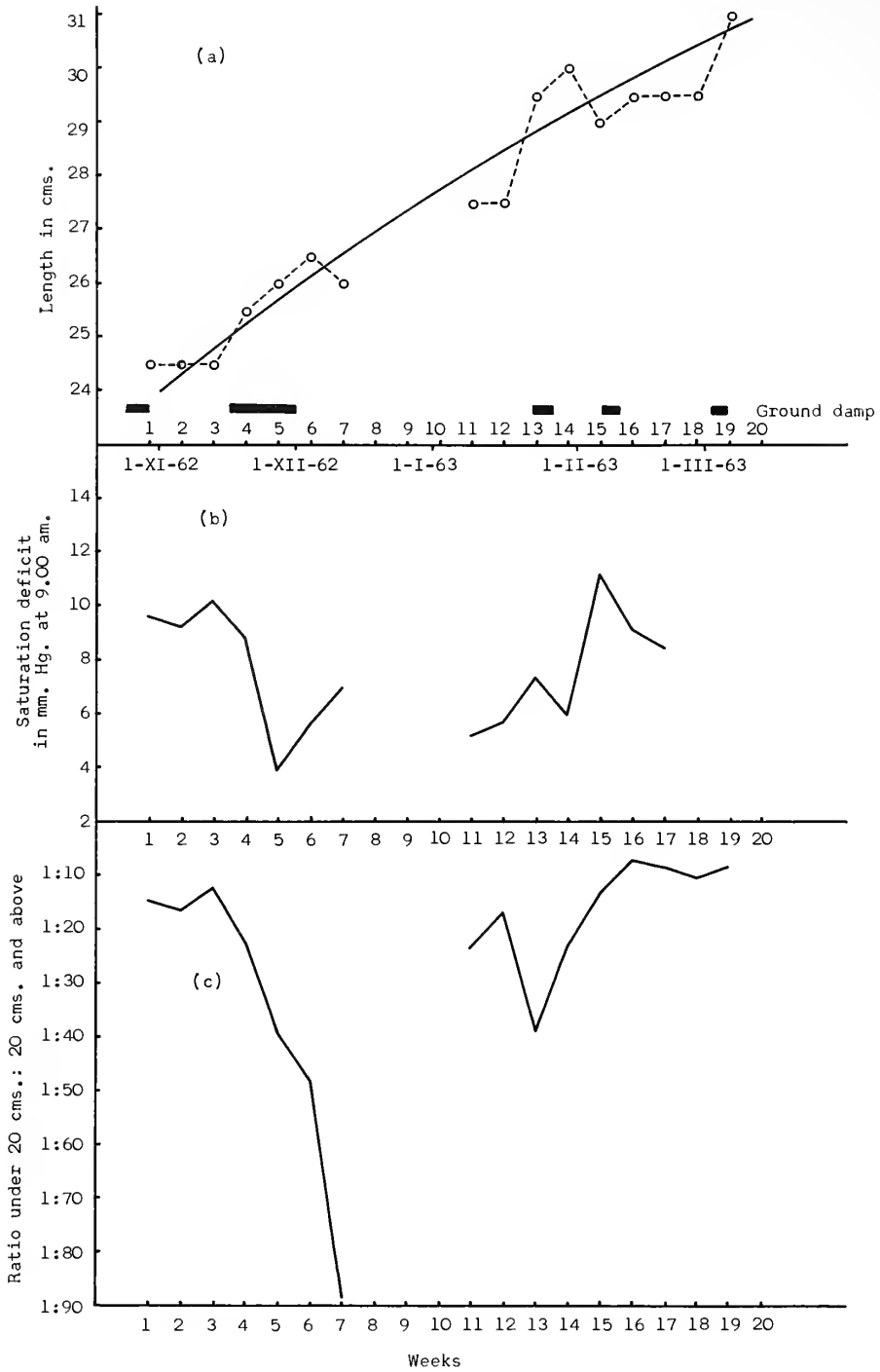

(a)
Length in cms.
31
30
29
28
27
26
25
24
Ground damp
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
1-XI-62
1-XII-62
1-I-63
1-II-63
1-III-63
(b)
Saturation deficit in mm. Hg. at 9.00 am.
14
12
10
8
6
4
2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
(c)
Ratio under 20 cms.: 20 cms. and above
1:10
1:20
1:30
1:40
1:50
1:60
1:70
1:80
1:90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Weeks

Fig. 3

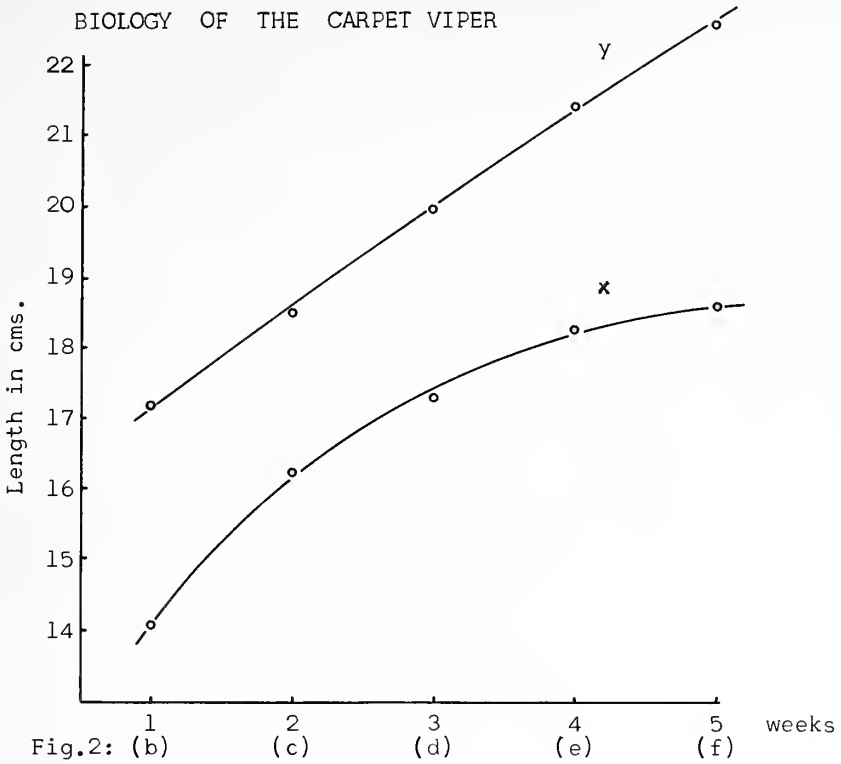


Fig.2:

Fig.4

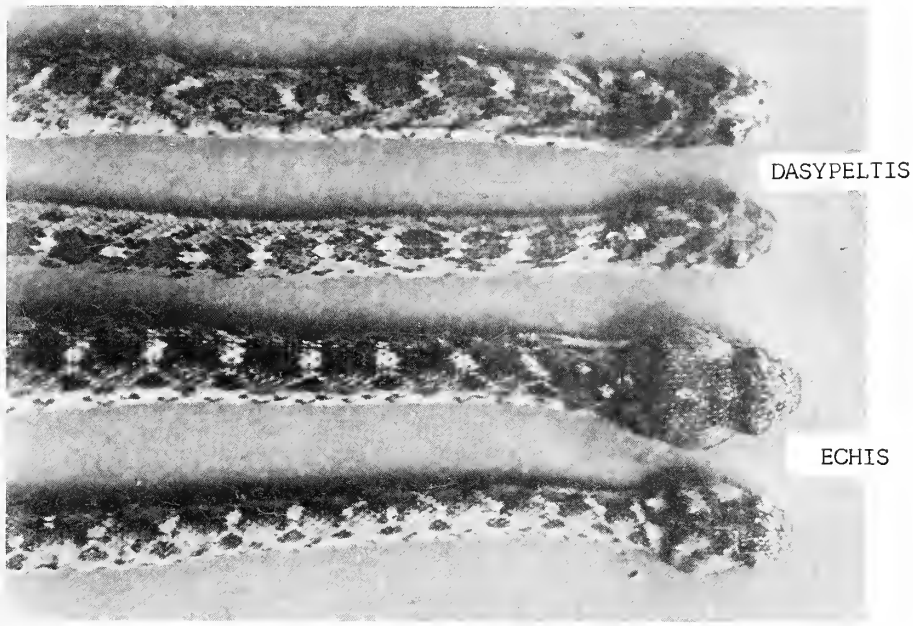


Fig.5

Echis and mimics (Dasypeltis)

REDWINGED STARLINGS OF KENYA

By

L.H. BROWN

The redwinged starlings of the genus Onychognathus, Stilbopsar and Galeopsar are a rather distinct and interesting group differing in several of their habits from other glossy starlings in East Africa. In all species the plumage is predominantly glossy black, with some grey about the head and neck in the females. In flight the primaries appear chestnut, usually in both sexes, but in Stilbopsar only in the female. The tail is usually elongated and graduated to a greater or lesser degree, and all species are more or less gregarious. With two other genera the Abyssinian White-billed Starling (Pilorhinus albirostris (Rüppell)) and the Narrow-tailed Starling (Poeoptera lugubris Bonaparte), which just reaches East Africa in Western Uganda, they form a convenient natural group or superspecies.

Six species of Redwings occur in Kenya, five of which I have seen and two of which I have studied in some detail. The observations on which the majority of this paper are based were made chiefly at Embu, on the eastern slopes of Mount Kenya, where I was Agricultural Officer between 1947 and 1952. In my garden there were a number of quick-growing Trema orientalis (L.) Bl. trees which produced an abundant crop of small black berries almost all the year round. They proved a great attraction to several species of starlings and other fruit-eating birds, including three species of redwings. Since leaving Embu I have made sporadic observations all over Kenya, but have never been able to do much more detailed work on any of the species concerned. My observations are summarised in the paragraphs which follow.

Genus ONYCHOGNATHUS

Onychognathus walleri (Shelley), Waller's Chestnut-wing Starling.

Two races of this species occur in Kenya (O.w.walleri (Shelley) of Kenya, and Kilimanjaro, and O.w.elgonensis (Sharpe) in western Kenya and Uganda. They are birds of forest at altitudes usually above 6,000 feet and there seems to be little difference in their habits. I have found both races rather uncommon and unobstrusive birds of the forest canopy, living usually in pairs or small flocks. I have seen the western race frequenting the dead trees of cultivation clearings and a pair of O.w.walleri were seen in the large Podocarpus trees at the Ngorongoro rest camp in January 1958. So far as my observations go the species is not so obviously gregarious as some other members of the genus. I have no personal acquaintance with their nesting habits, but in the Usambaras they have been seen breeding in holes in tall trees, while Jackson (3) records a nest with young 30 ft up in a tree in Nandi on 4th June. According to puplished records the breeding season appears to be protracted but is most likely to be concentrated during the rains. The eggs have never been described.

Onychognathus morio ruepellii (Verreaux), East African Redwing.

This is the East African representative of a species widespread in Africa which, with the march of civilisation, is becoming increasingly

commensal with man. In Kenya it is common in suitable localities East of the Rift, and as far North as the Matthews Range, but it is not common in most of Western Kenya except on Mount Elgon. Here I have found it fairly numerous among caves at about 5,000 - 6,000 ft. Another race O.m.montanus Van Someren is said to occur on the higher slopes of Mount Elgon above 9,000 ft and to differ from the East African race in having a more slender bill. Other races occur in South and West Africa, and are similar in their general habits to the East African race.

O.m.ruepellii is commonest about rocky inselbergs, where it frequents the rock faces in flocks of up to thirty, separating into pairs in the breeding season. It is not usually common in areas with rainfall of less than 25 inches, and in such areas is confined to rocky hills with small patches of forest. It roosts and breeds in holes in rock faces. On Mount Kenya and Mount Elgon it frequents caves and rocky gorges and I have not seen it above the forest line on either of these mountains. It is common in cultivated country of good rainfall provided there are suitable nesting sites, and has undoubtedly increased in numbers in such country with the increase in permanent buildings, bridges etc., that has taken place in the last fifteen years.

The best way of distinguishing this species from the Slender-billed Chestnut-wing is by its call, a sweet melodious whistle "Wheee-oh". The sound of this call proclaims the presence of the species round rocky crags where the observer cannot venture too close to the edge. This call, however, is similar to one call of Galeopsar salvadori. They also have a harsh alarm call "Chrraa", uttered when an enemy is near the nest. This note was also used by a male to threaten individuals of the closely related O. tenuirostris that came to feed in the Trema trees near my house, but was not used to other starlings e.g. Lamprocolius and Creatophora in the same trees. When soliciting food in courtship the female makes a chissiking call like a young bird, and when at the nest together the pair utter a variety of soft subdued whistles.

At Embu, where I studied this species closely, the natural habitat on the slopes of Mount Kenya was the deep-cut river gorges in volcanic rocks. Here the starlings nested in caves or under single volcanic boulders where these were large enough to provide an inaccessible and overhung nesting site. They also occurred commonly on rocky kopjes and hills at lower altitudes. Most nests in natural sites are inaccessible to predators and I found only one that I could reach without a ladder. All were substantial structures with a base of small sticks and vegetable fibres supported and held together by mud, with a cup in the centre lined with fine rootlets and grass stems.

With the spread of permanent buildings in Embu boma several pairs colonised the new nesting habitat, and the two known "building" pairs in 1947 had increased to at least six pairs by 1952. One pair lived in my chimney and were observed for four years continuously, and sporadically after that till the site was abandoned. The species also breeds in Nairobi, and a pair bred within earshot of my office in the Ministry of Agriculture in 1962 and 1963.

The pair that lived in my chimney were most attractive birds, nearly always together, and apparently very devoted to each other and to the nest site. In this they seemed typical of other pairs observed

round Embu, whether in a natural or a man-made nesting site. The nest site is used for roosting outside the breeding season, and all known nest sites have been used for many years in succession, though whether by the same birds is not known.

The pair in my chimney first attempted to breed in May 1947, but were discouraged by the fires we lit in that very wet year. I removed the nest, but they returned and built a new one during the short rains October-December 1947. In this case the nest cup was lined with the fine hair-like leaves of a Casuarina tree three hundred yards away in the District Commissioner's garden. The pair began to build in October but finally laid eggs only in January.

At the onset of the breeding season the male fed the female in the nesting recess, in one case with what looked like pawpaw (Carica papaya L.). Just after such courtship feeding both sexes would collect small sticks from a tree in my garden, but usually dropped them without taking them to the nest. The female would later go to the nest while the male perched in a Trema tree and sang in a series of soft whistles. Building began in earnest after this stage.

In 1947 and in subsequent years both sexes built or repaired the nest. The male brought most of the material while the female remained in the nest ledge working with what he brought. Sometimes she too brought material.

In 1947 the nest was reconstructed, beginning in October with a new foundation of mud, continuing through November with the addition of sticks, pieces of bark etc. and reaching the lining stage in December. On 6.1.48 the nest was complete but empty, and on 10.1.48 contained the full clutch. With this pair, therefore, the construction of a new nest took about three months, while the repair of the same nest in subsequent seasons occupied about six weeks. These prolonged periods are much longer than observed in the South African race (Rowan; 5). During the nest building and repair periods the pair roosted together in the nest recess.

1949 was an exceptionally dry year, with a near-total failure of the short rains in October-November. The birds did not breed in the chimney at the usual time, and visited the nest only sporadically. They did not begin nest repair in earnest till the early break of the long rains 1950, with heavy rain in early March. As in the case of the related O. tenuirostris the rains seemed to bring them into breeding condition with a rush. In March they began building rapidly, and had completed the nest by the first week in April. On 11th April it contained the full clutch.

In each year of observation this pair laid three eggs. They were laid on consecutive days, and were pale blue, handsomely spotted with red-brown, with lilac and grey undermarkings. A clutch of two from another nest, now in the Coryndon Museum, Nairobi, averaged 34.2 x 23.3 mm. Although these eggs were fresh the birds did not lay a second clutch after they were taken. All clutches I have seen were of three eggs, except the one noted above of two, (which may not have been completed). I have known clutches laid in August (1) October (1) November (1) December (1) January (2) April (1). The April clutch was clearly at an abnormal time due to unusual weather conditions and from observations of other nests with young it seems clear that at Embu the main breeding season was November to February.

Incubation proper begins with the completion of the clutch, although the female could have incubated at night since she slept in the chimney recess. Two complete incubation periods were recorded, both of 14 days. Broekhuysen (1) working with the South African O.m.morio recorded an incubation period of at least 25 days while Rowan (op. cit.) recorded a variation of 12-23 days, with an average of about 16 days. Such remarkable variations have yet to be shown in Kenya birds, which are perhaps under lesser pressure to complete their breeding cycle than are the South African birds living in a temperate climate, and could therefore be expected to have still more variable breeding cycles.

Almost all the incubation was done by the female, but on one occasion the male was recorded sitting. The pair slept together in the nest recess, and during the incubation period the male was usually in close attendance, perching in the Trema trees close by. He was not seen to feed the female in the nest, but may have done so. The female left the nest rather often to feed and when she did so the male went with her; the pair usually flew down into a valley and out of sight. On return the female would go into the nest, and the male again perch in the Trema trees. Such behaviour seems typical of the species (of. Rowan op. cit.), and of the related O. tenuirostris.

The young of the Embu birds hatched simultaneously, indicating that incubation had not been consistent, even at night, until the clutch was complete. Rowan (op. cit.) records a difference of about 48 hours between the hatching the first and last eggs in just over half the observed cases, and simultaneous hatching in others. For some time after the hatch both sexes roosted with the brood in the chimney recess and were often noisy until quite late at night.

In the early fledging period the female spent much time in the nest brooding the young, and the male brought food. After a few days, however, it was usual for the pair to go off together to fetch food, and return together. At this time both sexes fed the young, but the female rather more than the male. Up to the 14th day of the fledging period the female spent periods in the nest brooding the young after she had fed them; during these periods the male either sat in a nearby tree or went away alone and returned with more food. Most of my periods of observation were short, but an analysis of 13 hours watching on four days, gives an average feeding rate of just over 2 feeds per hour. This is a very much lower average rate than recorded by Rowan in South Africa, where the average rate was 8-12 feeds per hour with a maximum of 20 per hour. In my Embu birds the slower rate of feeding did not seem to have any adverse effect on the growth of the young. The feeding rate could easily have been accelerated had this been necessary. There was a tendency for the pair to bring several feeds in quick succession, followed by a break, and then some more. More feeds were given before 10 a.m. than at other times of the day. During the middle of the day the pair usually sat in the trees near the nest and scarcely fed the young.

The majority of the food brought to the young was fruit, particularly Trema berries. Other vegetable food brought included mulberries (which the young rejected and the male then swallowed), a kind of paste, looking like maizemeal porridge, and other small berries. Some of the food was indistinguishable and looked like a mash of insects, but most of the insect food consisted of large insects such as stick

insects, mantids and grasshoppers. One large spider was brought to the young. The proportion of vegetable food to insect was probably at least two to one, possibly more.

Both sexes removed faecal pellets from the nest, and the male was seen to do so more often than the female; this may have been mere coincidence as few faecal pellets were deposited during the periods of observation.

Despite their devotion to the site and their general behaviour these birds were extraordinarily unsuccessful in rearing young. In each of four years they laid three eggs, yet they only succeeded in rearing one young one altogether, and that one a doubtful starter. In the first year, 1947, the three young disappeared at about 14 days old, probably taken by a cat at night. In 1948 one young one died in the nest early, and despite a precautionary barrier the other two fell down the chimney while I was away from home. One was dead when we found them and the other had a broken leg; I replaced it in the nest but it fell out again and finally died when it was 21 days old. In April 1950 the season of delayed breeding, two young disappeared from the nest and there was only one left 14 days after hatching. Again, despite precautions, this bird fell down the chimney while I was away, and the parents followed it down and fed it in my sitting room. It was 24 days old when found and would not remain in the nest when replaced. It could fly fairly well and was placed on the roof of an adjacent building where the parents fed it; it may have survived. The pair bred again in December 1950, but the young disappeared almost at once, taken by some predator. After the disappearance of the young in each year the parents continued to frequent the house and chimney, but never made an attempt to rear a second brood. I had evidence that this very low rate of breeding success was abnormal; other pairs in more inaccessible situations in roofs of other buildings seemed to be more successful.

This pair of starlings did not attempt to breed at the end of 1951 and eventually deserted the garden in 1952. The Irema trees, which are very brittle, began to shed their branches as they grew old and had to be cut down. Possibly the removal of this readily available source of food a few yards from their nest was a contributory cause of the abandonment of the site, which has not been occupied by another pair since.

Onychognathus tenuirostris (Ruppell), Slender-billed Chestnut-wing.

Two races of this species occur in Kenya O.t.tenuirostris found on Mount Kenya, and O.t.theresae Meinertzhagen, on the Aberdares and west to Ruanda Urundi and south to S. Tanganyika. The races are only doubtfully distinct. I have seen O.t.tenuirostris in the highlands of Ethiopia and I have studied both races closely in the vicinity of Nyeri, and can state that there is no practical difference in their habits. The headquarters of the species in Kenya is on Mount Kenya and the Aberdares. It is not common on Mount Elgon or on the Mau range. In Ethiopia it is numerous in Semien but uncommon East and South of the Rift Valley.

This is one of the most delightful of all our starlings, gregarious at all times, active, excitable and noisy. As a rule it is not found below the natural level of forest but is common in cultivated areas in the former forest zone on Mount Kenya and the Aberdares. It goes up onto the high moorlands of the mountains to feed, but it is

typically a bird of the forest zone, from 4,500 to 10,000 ft. Although flocks move about a great deal they are always based on river valleys, and roost and breed in caves under and near waterfalls. Indeed, it is probably the geological formation of Mount Kenya and the Aberdares, which results in numerous small waterfalls with caves in the softer material under a hard rock sill that enables the species to be so common there. There are far fewer suitable breeding and roosting caves on Mount Elgon, or the Mau range.

This species is easily distinguished from O. morio by the following features (i). It is intensely gregarious, hardly ever seen except in flocks, which are usually large (ii). Its calls which, in contrast to those of O. morio, are sharp and piercing. A characteristic alarm note when taking wing is a high-pitched "pleek", and a flock keeps up a continuous sharp whistling and chattering. It never emits a mellow whistle like O. morio. (iii). In adults the two central tail feathers are more elongated than the rest, and project as a distinct stub (diagram); this character enables individuals to be recognised (iv). It is a much more active, quick-moving, and excitable species generally, and strongly attached to water.

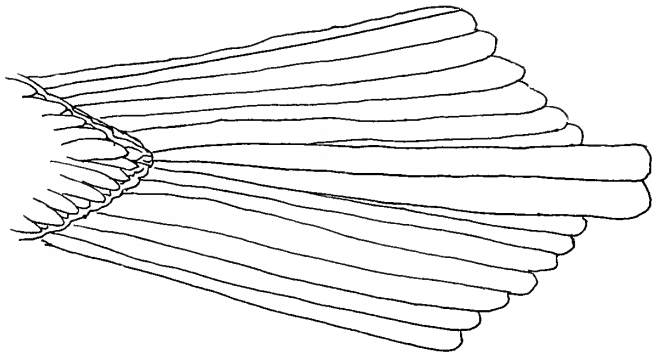
It would be more difficult to distinguish O. tenuirostris from the Bristle-crowned Chestnut-wing, Galeopsar salvadori, which has a very similar flight silhouette with elongated central tail feathers. However it is very unlikely that the two species would be seen in the same type of country, and the bristly crown of Galeopsar is diagnostic at close range.

Flocks of this species live in caves in river gorges, almost always near a waterfall. A favourite roosting cave is at the waterfall on the Chania River just above the Outspan Hotel at Nyeri. The birds generally roost on dry ledges beside the fall, but sometimes enter the cave behind the falling curtain of water. Not all roosting caves are used as breeding sites.

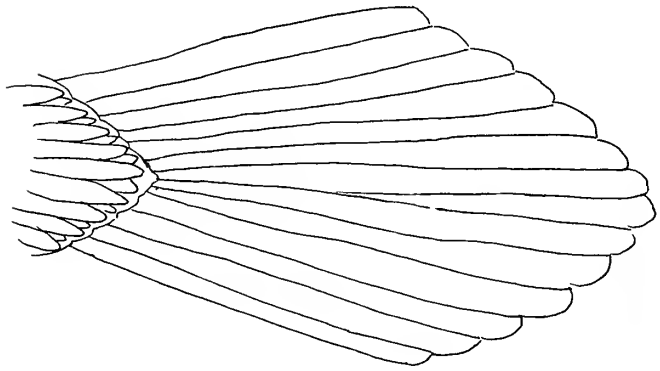
The general habits are to leave the roosting cave early in the morning and to move to a favoured locality. At certain seasons flocks of hundreds used to feed in the Trema trees in my garden at Embu. In 1947, a year of heavy rainfall, they were absent from April to June, but present for the rest of the year. Local movements appeared to vary a good deal according to the rains, and were probably connected with the availability of favoured food supplies. The Trema trees were nearly always in fruit, hence the starlings spent much time in my garden.

The birds return to their roosting caves in the evening, from 4.p.m. onwards. Before roosting they often bathe in the stream, but not necessarily at the roosting site. At the Outspan cave the number roosting reached a peak in March with 80-85 birds. On 5.11.52 there were 40, on 28.2.53 60-65; and on 17.4.53 again 60-65. Where a roosting cave is also a breeding site the numbers roosting are invariably far in excess of the breeding birds. At a small waterfall at Karurumwe in Embu district there were regularly 20-30 roosters, but only two nest sites. Of 34 counted one evening only 6 were adult females, the rest males and immatures. In fact the breeding birds would seem to be only a small proportion of the total population of the species.

The species is common on the moorlands of Mount Kenya and the Aberdares, but it is not so common generally at high altitudes as in



Tail of
Onychognathus tenuirostris
adult



Tail of
Onychognathus morio
adult

the cultivated areas below the forest. It has been seen at above 15,000 ft. around the high crags of Point John and above Two Tarn Col, but flocks usually stick to the zone of vegetation. Here they frequent cliff faces, going in and out of holes, and it was probably this that led Mackinder to suppose that they bred at these high altitudes in August (Moreau: 4). Inter alia these starlings feed on small, yellowish, soft-shelled snails on the high moorlands (J.G. Williams, in litt.) They also feed among giant lobelias both in Kenya and Ethiopia. In Ethiopia they ascend to the high moorlands of Semien daily, returning to caves low down on the tremendous crags at night. Occasionally they roost at high altitudes; for instance a flock roosted in a cave at the base of Hall Tarn Crag on Mount Kenya on 13.3.52. But it is probable that most of the birds seen on the high moorlands of Mount Kenya descend to lower levels to roost. This view agrees with Chapin's (2) observations.

The Slender-billed Chestnut-wing breeds singly or in small colonies in caves under waterfalls at altitudes from 4,300 - 7,000 ft. I have found nests also at 3,800 ft. on the Nyamini River in Embu district, and at 10,500 ft. on the Kathenju River at the upper limit of forest on Mount Kenya. The highest nest I have found was in a cave at a waterfall above the Nithi Falls, at about 11,000 ft on Mount Kenya. But these upper and lower nests were apparently not occupied at the normal breeding season for the species, and it remains to be proved whether they ever breed successfully above or below the forest zone. There is, for instance, no visible nest under the very suitable Queen's Fall on the Aberdares.

The nest sites in the caves are usually in moist but not very wet situations. They are inaccessible because of the falling water and are sometimes placed on the rock face among vegetation such as ferns and moss, at other times placed in dark crannies in the depths of the cave behind the fall. I have found one nest at the end of a tunnel, in partial darkness. Most suitable waterfalls have several pairs nesting behind them, but the largest number of breeding pairs found at any waterfall was four. In the caves the nests are spaced well apart, and there may be suitable sites without a nest. Although colonial and gregarious therefore, this starling appears to maintain a definite spacing between actual nest sites. The immediate vicinity of the nest site is defended by the male, who drives away immatures and strange adults that often come to bathe in the falling water.

The nests are built of moss on a foundation of mud, and lined with grass. Both sexes build and the share of the sexes is fairly equally divided. At one nest near Nyeri the male made three and the female four trips with moss in 25 minutes. The nests are likely to disintegrate during periods of flood, when the caves behind the waterfall are soaked with spray, and they have to be largely rebuilt each year. The same sites are used year after year, presumably by different birds. One site known is still in use sixteen years after it was first found in 1948.

Nest repair and other activities appear largely to be controlled by the level of water in the river. When the river is in flood the birds cannot build or breed, and they must wait till it recedes. Equally, in periods of drought, breeding seems to be inhibited. At one colony, on the Kapinazi River at Embu, the failure of the short rains in October 1949 shrank the river to nothing, and though the main breeding season is October-March the birds here did not begin nest repair

till early in March after the first rains had restored some flow in the river. Nest repairs may be prolonged over four months from October to February, or it may be short and compressed as in the Kapingazi colony in 1950, when the birds came into breeding condition with a rush and had laid eggs ten days after the onset of marked activity. The general pattern probably varies with the site. On a small river the flow of water is sometimes not great enough to prevent activity even in the rains, but on larger rivers breeding must be concentrated in periods of low water. At the same time the larger and more successful colonies are probably situated in inaccessible caves behind waterfalls on the larger rivers.

Two to four eggs are laid on consecutive days. In eleven clutches there were 1 C2, 8 C3, and 2 C4: mean 3.1. The eggs are clear pale blue, sometimes finely spotted with red-brown all over, or sometimes with larger, more blotchy markings. Three eggs averaged 33.5 x 32.8 mm. If a clutch is taken a second may be laid; a clutch of three taken for the Coryndon Museum on 1.2.48 was replaced by 23.3.48. Clutches have been found as follows (Some laying dates estimated from young in the nest) September, 1; November, 1; January, 2; February, 10; March, 7 (including one replacement clutch). The September and November nests were in the Aberdares near Nyeri, all the others in Embu or Meru districts on Mount Kenya. Thus although the breeding season is rather variable it appears to be concentrated between January and March, a dry season with minimum water levels.

Incubation begins with the completion of the clutch, and takes 13 days or a little less. In three observed cases there was no variation in the incubation period. The female alone incubated in all observed nests, and she was fed at the nest by the male. She would sometimes leave the nest at the male's approach, perch on a boulder and solicit him with beak open (presumably calling, but inaudible in the roar of the fall). The male usually regurgitated food he was carrying in his crop direct into the female's bill. Sometimes he visited the nest site without food; on such occasions the female would leave the nest, solicit unsuccessfully, and return after a few moments.

The young are feeble and quiescent when first hatched, but become quite active by the third day. Even at this early stage they are left alone in the nest by the female for considerable periods. The female alone broods the young, brooding all night and for periods during the day. At two nests with young two and tree days old females brooded during most of a morning's observations. In 195 minutes at one of these nests the female was brooding for 130 minutes and off the nest for 65 minutes, in 8 spells varying from 2-16 minutes. Her spells off were invariably associated with the visits of the male. In this time he fed the young four times and the female once, and paid five visits without feeding either young or female. The female fed the young three times, twice with food she had received from the male and once with food she had collected herself. After one visit by the male she fed young twice in succession, with an interval between feeds, with food received from him. On each of the male's visits the female would solicit him, sometimes leaving the nest to do so, and on one visit she was fed first before any food was delivered to the young. The nature of the food could not be ascertained as all was regurgitated. From observations at other nests this sort of behaviour seemed to be usual in the early fledging period.

Later in the fledging period the young were left alone in the nest

for much of the time and the pair went off together to collect food, as in O. morio. At this stage they seemed to be very devoted to one another, and were usually in company, even when perched. The female appeared to stop brooding the young much by day after about 10 days, and when the pair returned together after a food foray she generally fed the young first. Both sexes removed faecal pellets, but the male seemed to do so more often than the female. The young can deposit faecal pellets outside the nest at 14 days old.

An experienced African observer, Njeru Kicho, who had worked with me for a number of years at several eagles' nests, watched at the colony from 11.4.50 to 4.5.50. He was required to record, by notching sticks, the number of feeds brought to each of three nests A, B, and C, on each day. When the observations began Nest A contained young 13 days old, Nest B young 12 days old, and Nest C young 19 days old. In 65 hours observation on 18 days, between the hours of 8 a.m. and 4.p.m., but not the same hours every day, he recorded 465 feeds, 186 at Nest B with the smallest young and 127 at Nest C with the largest young. The average rate of feeding at all nests was 2.4/nest/hour in the first four consecutive days 11-14.4.50, and fell to 1.74/nest/hour in the last four consecutive days 26-29.4.50. Two days afterwards, on 1.5.50, a feeding rate of 2.89/nest/hour was recorded, and on 4.5.50, when the young in Nest B and C were free of the nest, the rate had fallen to 0.83/nest/hour. The highest individual rate of feeding was 5.0 feeds/hour at Nest B on 18.4.50 and the lowest, apart from the last days observation, 1.1/hour at Nest A on 26.4.50. These observations are quite consistent with an average rate of feeding of 2.38/nest per hour recorded by myself at Nest A, from a hide, on 2 and 6.4.50.

The behaviour of the females was largely controlled by the level of water in the rivers. 13th-15th April was a period of heavy flood. At nests A and B, which on 13.4.50 contained young 15 and 14 days old respectively, the female remained in the nest all the time and received all food from the male. Even at Nest C, in which the young were 21 days old on 13.4.50, the female remained beside the nest all the time and did not leave to feed. Thereafter the water level fell somewhat, but remained consistently high till the end of the observation period. In the following week, however, when the young in nests A, and B, were 22-23 days old, and those in nest C were about 30 days old, they were left alone in the nests by the females despite further heavy floods.

In fact these young must have been almost fully fledged at this time. In 1949 at the same colony the fledging period was recorded as at least 23 days and probably slightly longer. In the closely related O. morio the fledging period is about 24 days in Kenya. In normal circumstances, with eggs laid in January or February, the young would be able to leave the nest in February or early March, when water levels are at their lowest. But in 1950, when the birds did not start to breed until the onset of the long rains in March, the young remained much longer than usual in the nests. The young in Nest C had only just left the nest on 4.5.50, when they were 42 days old; those in Nest B, 35 days old, left the nest to receive food but returned to it later, and those in Nest A had not left when 36 days old. Thus they must have remained in the nest, though probably quite able to fly, for at least ten days longer than normal. This can only have been due to the high level of the river.

After leaving the nest young and adults return to the vicinity to roost. The sexes are indistinguishable in the immature plumage, the

grey head of the female being acquired with maturity. Flocks of immatures and unattached adults often visit the nest site while breeding is in progress, and if they go too close to the nest sites they are repelled by the breeding males. However, adults will feed young with immature birds perched within a foot or two of them. The age at which adult plumage is acquired is not known, but adult breeding females are always a small proportion of the combined flock at a breeding site. Further information is needed on the total population in relation to the number of nest sites, but all the available evidence is to the effect that it is impossible for all available adults to breed annually.

Breeding success in the Kapingazi River colony in the two seasons in which it was observed was rather low. In 1948, from four nests in which at least 12 eggs had been laid, only five young certainly hatched, and of these only one flew. In 1950 at the same colony, of 13 eggs laid in four nests three were lost in incubation, and one was addled in Nest C. Of the nine young that hatched six flew. This gives a mean breeding success in two years from four nests of 0.88 young per pair per annum - no better than in many large raptors. Of eggs laid 28% produced fledged young; and of young hatched 50% reached the flying stage. Observations at other breeding sites tend to confirm that this poor performance is usual. Inaccessible nests, either high up on the rock face among vegetation, or in deep caves behind difficult falls, may have a higher rate of success than easily accessible nests in dry caves; the one easily accessible Kapingazi nest failed in both years.

The small proportion of breeding females, and the rather low breeding success achieved even by those indicate that to attain the numbers that actually exist the species must be long-lived. Further quantitive observations, if possible supported by ringing, are needed to elucidate these points.

Galeopsar salvadori Sharpe, Bristle-crowned Chestnut-wing.

This species is an inhabitant of semi-arid country from north of the N. Guaso Nyiro to Turkana, and southwards down the Rift Valley to the neighbourhood of Lake Hannington. I have found it locally common at Marsabit and in the Turkwell Gorge in Turkana, where it is very common and takes the place of Onychognathus morio. In Baringo district it is rather uncommon, frequenting chiefly the vicinity of rocky gorges.

At Marsabit flocks seasonally visit the township area, and come to drink at a small pool in the Regional Government Agent's garden. Here their behaviour is very reminiscent of the chattering flocks of Slender-billed Chestnut-wing C. tenuirostris in Embu township. The birds would come down to the pool in ones and twos till it was surrounded by a ring of them. They would then take sudden alarm and fly to trees in the garden, whence they would again gradually descend. When drinking they often drank in unison, all lowering and raising their heads together. This drinking behaviour was seen on 23-24.9.60, but not on subsequent visits on 21-22.3.62, or on 9-11.10.63 or 9-10.12.63. It is possibly connected with severe drought conditions. In September 1960 they had evidently been feeding on purple fruits.

In its general habits this species behaves like a combination of O. morio and O. tenuirostris but its range is different and its normal habitat is much drier. I have found it most commonly frequenting the larger trees along drainage lines, but have also met with it in thin open thornbush. At Marsabit and in Turkana it is fond of rocky places, like O. morio.

At close quarters this species can be distinguished from any Onychognathus species by its crown of bristles, which gives the head a distinctive silhouette. However, this is not as obvious in the field as it might seem. In flight it can be distinguished from O. morio by the projecting elongated central tail feathers. Calls are no help at all. At Marsabit the drinking birds were heard chattering shrilly in the manner of O. tenuirostris, and they also emitted a similar but rather lower-pitched and harsher "kleek" than that species. However at the Turkwell gorge they were at first confused with O. morio because of the sweet whistling cries "sweee-oh" they uttered. These calls do not appear to have been described before.

Stilbopsar kenricki (Shelley), Kenrick's Starling.

This species, found in Kenya east of the Rift and Tanganyika is barely distinct from Stuhlman's starling S. stuhlmanni of Western Kenya and Uganda. The race found on Mount Kenya is S.k.bensoni Van Someren. It is a forest bird which occurred seasonally at Embu as low as 4,500 feet. Flocks frequented my garden at the height of the rains, in May 1947, and again for some time in July 1947, when there was heavy mist. They only visited my garden in the wettest weather and in years of heavy rainfall; they did not come at all in 1948 or in 1949, and in 1950 only came in May. These visiting flocks probably came from the Njukiini forest not far away, and like other starlings at Embu they fed in the Trema trees. They were, however, present at a time of year when hardly any other starlings were in the garden. Four specimens were collected in 1949 and are in the Coryndon Museum, Nairobi.

The nest is made in a hole in a tree, but the eggs have never been described. I saw a pair prospecting an old barbet's hole in a dead tree on the edge of Njukiini forest in 1948, but was unable to reach this possible nest site. On a later visit the birds were not seen and had probably not bred in the hole.

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(Received 18th November 1964)

PLATE I Female on ledge below nest, showing shape of tail

PLATE II Male feeding young, female obscured behind him

PLATE III A short-tailed immature "visiting" the nest; such birds are repelled by the adults

PLATE IV Typical breeding site of single pair. The nest, accessible only after a swim, is among the vegetation to the right of the waterfall

SOME NOTES ON XENOPUS LAEVIS (Daudin).

(AMPHIBIA, PIPIDAE)

By

J.A. WOOD

Introduction

The Clawed-frog, Xenopus, is commonly found in the streams and other waters around Nairobi. The animal has a distinctive appearance because of its dorso-ventrally flattened body and small eyes; the skin is always very slimy, more so than that of Ranid frogs. Xenopus is an almost fully aquatic animal and the writer has never yet seen one on dry land.

The Adult Frog

Description. Around Nairobi the usual length of a mature specimen is about 6 cm. (nose to cloaca), the females being larger and heavier than the males. The colour is greyish-brown dorsally, appearing sometimes to be almost black; the belly is silver grey but some specimens have this colour as a ground, mottled with mustard yellow. Two individuals coloured this shade of yellow all over are in the writer's possession.

The flattened head bears the eyes on its dorsal surface, each eye being covered by fixed lids with only a very small round aperture. Vision is apparently limited to an area vertically above. Below the eye on each side is a small projection derived from the tentacle of the tadpole. The nostrils are prominent at the front of the upper jaw.

The four digits of the fore-limbs are free but the five digits of the hind-limbs are fully webbed, and digits I, II and III have each a shiny black claw which gives the animal its common name. A metatarsal tubercle is present, and in other species of the genus this carries a small spur.

The skin is smooth and slimy to touch because of the many mucous glands; this feature makes the frog extremely difficult to hold and is doubtless of great survival value. A conspicuous line of white dots is visible on each side from eye to vent along a dorso-lateral line; each dot is a gland or organ, and much discussion has centred around their function. Vertical sections of the skin shew that these structures are epidermal only, and connections from them to the lateralis branch of the vagus indicate that they are lateral line organs, but the lumen of the organ is filled with corneified cell debris and for this reason some authorities doubt whether the organs are functional. (1)

Sexual dimorphism is limited but the cloaca (vent) of the female is closed by three cutaneous flaps and that of the male by two, (Fig. 2). In the mating season, the male develops a black nuptial fringe

along the inner side of the fingers which enables him to obtain a better grip on the female.

Systematic Position and Distribution.

The genus Xenopus is a member of the sub-order Pipidae, order Aglossa, sub-class Anura, class Amphibia.

Xenopus is confined to Africa, and East Africa boasts two species, X. laevis (Daudin) and X. muelleri (Peters). The former is found from the Cape right through to Ethiopia and the latter from Zanzibar to Benguela. In West Africa only, is found X. calcaratus. Some authorities have split off X. laevis victorianus (Ahl.) and X. laevis bunyoniensis (Lov.) and would raise them to the rank of species. (2).

Other genera of the sub-order are Pipa, Protopipa, and Hemipipa, all from the New World, and Hymenochirus and Pseudohymenochirus both found in Africa (3,4).

General Anatomy.

As the name of its order indicates, Xenopus has no tongue; nevertheless, the hyoid is present and easily seen in the floor of the buccal cavity. Like other members of the Aglossa, the Eustachian tubes unite and have a common opening into the pharynx; it lies medially in the rear palate. Teeth are present in the upper jaw only.

The lungs contain little free lumen because of internal projections called trabeculae. Here is a difference from Ranid frogs whose lungs are simply air-sacs with a vascular lining; the lungs of Xenopus are considered to be much advanced functionally over those of the Ranidae. It is interesting to note that Xenopus spends long periods floating vertically in the water with just its nostrils exposed. In correlation with this developed lung is to be noted the so-called diaphragm, a web of muscle stretching from the ilia to the base of the lungs. As in all Amphibia, the skin is highly vascular. (5-7).

The skeletal structure of Xenopus and other Aglossa differs from that of Ranid frogs in a number of features concerning the vertebrae, the sternum and the lower jaw. The vertebrae are opisthocoelus (concave at the rear face) and the 2nd. 3rd. and 4th. carry long ribs which in old individuals are found to be fused with the diapophyses. The sacral diapophyses are broad and the urostyle is fused with the sacrum and not articulated with it as in the Phaneroglossa. The sternum is slender, and there is no presternum. A small prepubic cartilage is present. The lower jaw is noteworthy in so far as no Mento-Meckelian cartilage is present.

Habits.

Xenopus is fully aquatic, and as mentioned in the introduction, the writer has never yet found one out of water, not even in reeds or other vegetation bordering a stream or pond. A record does exist however, of a large number of X. laevis borealis migrating along a front ten yards wide between two ponds fifty yards apart. This occurred in 1934 on a farm near Eldoret, in conditions of heavy dew and soaking

wet grass. (8).

The adults appear to be exclusively carnivorous and in the wild state are very probably scavengers although they are not averse to taking small worms, Dipteran larvae, and tadpoles - including those of their own species.

Ingestion is brought about by the front legs which serve as hands to push food into the mouth. The motion of the hands begins soon after food is located in the vicinity, and the animals begin to swim in random erratic movements until, so it appears, they arrive directly in front of the food; this is then caught by the constantly moving hands and pushed into the mouth. It seems that the hand movements are a reflex response to the presence of food indicated by chemo-reception; the idea is supported by the fact that a few drops of water soluble meat extract elicits the same response. Such behaviour would be of great value in the conditions of poor visibility common in the muddy water where Xenopus is usually found. In the event of a piece of food being found which is too big to swallow, some portion of it is pushed in the mouth and then shredded from the rest by rapid kicks with both front and rear feet, armed as the latter are with claws.

In captivity, Xenopus feeds well and thrives on a diet of chopped raw liver; beef is also taken well, both lean meat and fat; on one occasion when python meat was available, it was taken readily.

Parasites. On two occasions, once in the Coryndon Museum, March 1961, individuals have been seen swollen like balloons; investigation has shown that this is because of excessive quantities of liquid in the lymph sacs. It is thought to be because of a helminth infection, (2, 8).

Respiration. Observations on the animal in the field and in captivity, make it apparent that Xenopus inhales a great deal of atmospheric air. Even in well aerated aquarium water, the animal rises to the surface at regular intervals; these intervals vary with the size of the frog, the water temperature and other factors, but are usually about seven minutes. While lying submerged bubbles are emitted periodically from the lips. Sometimes, Xenopus may adopt a nearly vertical posture in the water, floating with its nostrils just exposed on the surface; during such periods, the nostrils can be seen to be opening and closing rhythmically. In correlation with this behaviour it should be noted that the lung is of an advanced form when compared with other Amphibia.

Despite these facts, the skin is highly vascular and there is little doubt that gaseous exchange occurs through the cutaneous capillaries. Whether buccal respiration occurs as in other frogs, the writer has not been able to determine.(10-12).

Breeding. This occurs in the field with the onset of the rains; in the Nairobi area therefore, breeding occurs twice a year. The mating call of the males is a short, repeated tock-tock-tock-tock- sound, rather like the noise of a stick being run along a fence; this noise is made under water, but is clearly audible if the frogs are in an aquarium. The mating attitude (amplexus) is different from that seen in other frogs, the male Xenopus seizes the female around her thighs and not under the fore-arms.

The eggs are laid singly attached to leaves of water plants, but no local records exist of eggs of Xenopus ever being found and positively identified as such. Nevertheless, the tadpoles of Xenopus are plentiful in the Nairobi area and are easily recognized. (13-16).

It is difficult to measure or to estimate the life span of Xenopus; Nigrelli gives a figure of fifteen years, but it is doubtful whether any individual attains this age in nature. (17).

The Larva.

Description. The young tadpole, up to about 15 mm. in length, is virtually transparent except for two black pigmented areas around the eyes; these give away its presence in the water to an observer in the air above, but it is probable that the tadpole is invisible to other water living animals. The shape is characteristic; the head is flattened dorso-ventrally and the gape is very wide; a long tentacle projects from the corner of the mouth on each side. The tentacles approximate to half the body length, but their function is uncertain; they may act as balancers to assist them to maintain their head-down attitude in the water. The eyes have a key-hole shaped pupil. The abdominal region is pear-shaped in section, and a conspicuous hump is visible; ventrally, the pericardium is visible by its silver colour. Two long slit-like spiracles allow water to be voided from the branchial chamber; they lie to the left and right of the midline on the ventral surface of the abdomen. A little Indian ink or carmine placed in front of the animal's mouth demonstrates that both spiracles function. The tail is long, and in life the last part of it is held up at an angle reminiscent of the heterocercal tail of sharks.

The period of time spent as a tadpole varies, as it is affected by the food supply, water temperature and amount of oxygen present in the water. In the Nairobi area, it is usual however for metamorphosis to begin at about six weeks and be completed by the twelfth. A larva begins to feed in the adult manner once the fore-legs have developed.

Interest in the tadpole, for one person at least, is centered in its breathing and feeding, and these activities are based upon the form of structures associated with the pharynx.

The Pharynx. In any tadpole over 1 cm in length there are six clearly visible visceral arches, (Fig. 3) counting the mandibular arch as the first; this is followed by the hyoidean arch, but the hyomandibular cleft does not break through. The third visceral arch is the first branchial, and is posterior to the first branchial cleft which lies in the pharyngeal floor. The outer corner of this cleft is level with the eye on each side, and the cleft descends almost vertically to open by a narrow slit into the branchial chamber. The three succeeding branchial clefts are all much larger than the first, and each intervening branchial arch supports a large curtain-like gill septum. These septa have an interesting structure; each is roughly semi-circular and is bounded by an afferent branchial artery connected to an efferent branchial artery by a series of vertical commissures. There are a number of lateral vessels too which provide inter-connections between the commissures. The vertical commissures open out into a complex series of sacs which give rise to a visable series of vertical bands on the septa (Fig. 4). These sacs are absent on the anterior face of

the first branchial cleft, and on its posterior face they are simple and unbranched. The sacs reach their maximum development on the sept supported by branchial arches 2, 3, and 4; on the posterior face of the last cleft the sacs are less complex, (Figs. 5 and 6).

Gaseous exchange will occur as water drawn in through the mouth passes downwards through the clefts into the branchial chamber; this water is separated by only an epithelium from the blood rising upwards through the commissures and their sacs, hence conditions are ideal for the diffusion of oxygen into the blood from the water and for the diffusion of carbon dioxide in the reverse direction.

The ventral openings of the branchial clefts into the branchial chamber are not uniform. Branchial clefts I, open by means of a pair of lateral slits level with the posterior edges of the eyes; branchial clefts II, open some distance behind, via lateral slits on each side just anterior to the heart; clefts III & IV, open on each side into a shallow vestibule at the side of the heart, (Fig. 7).

Nutrition. An examination of the gill septa of a fresh specimen, reveals that each septum is covered with a thick layer of mucus in which are embedded vast numbers of algae and other freshwater plankton; the same material is found in the stomach and indicates that the tadpole is a filter feeder. Plankton and other suspended matter is trapped on the surface of each septum as the water flows over it. A current of mucus doubtless conveys the material from each septum to the oesophagus, but it has not yet been possible for the writer to map these currents; it is hoped that they will form the subject of a second paper.

The filtering is carried out while the tadpole lies still in the water, head downwards at an angle of about 60° from the horizontal. This attitude is maintained for long periods of time and the only visible movement is a rapid serial contraction of the tail; the movement of the waves is clearly seen near the tip of the tail where it becomes a rapid flicker. During this activity, the tip of the tail is held almost vertically, and presumably, enough lift is obtained from the tail just to counteract the tadpole's weight, for it neither rises nor sinks. However, when the movement of the tail stops, the tail gradually falls below the level of the head, and the whole animal sinks. From time to time, a tadpole will swim to a new area of water.

The mechanism of the tail action is rather puzzling for if the waves along the tadpole's tail were of the normal form, the machanical effect would be to drive the animal forward along its own longitudinal axis, yet the waves do not start terminally, nor can one imagine them doing so.

So far as the writer has seen, Xenopus has little appeal to the layman but it is a common creature and repays study. The frog is being used for research into cancer at Oxford and for cytogenetic studies at Geneva, but its claim to fame lies in the use of the female for the determination of pregnancy in women; a positive result can be obtained in twenty four hours. In this connection, it is interesting to note that South Africa is the world's supplier of specimens and exports them all over the globe: even Kenya, where Xenopus abounds, imports them from South Africa for this purpose.

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Further Recommended Literature

A useful general introduction to the study of the genus Xenopus is contained in "Amphibia and Reptiles", Cambridge Natural History Series, MacMillan & Co., reprinted 1923. There is an article too in African Wild Life, 9.

A most useful source of information is Nieuwkoop and Faber, "Normal Table of Xenopus laevis". Amsterdam.

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Xenopus laevis tadpoles
x 0.50

Fig. 1 Tadpoles in feeding attitude x 0.75

Right: Xenopus laevis borealis ♀
Left: Xenopus laevis laevis ♀; on this specimen the line of epidermal glands is clearly visible. x 0.50

Fig. 2 Xenopus surfacing to breathe atmospheric air x 0.50

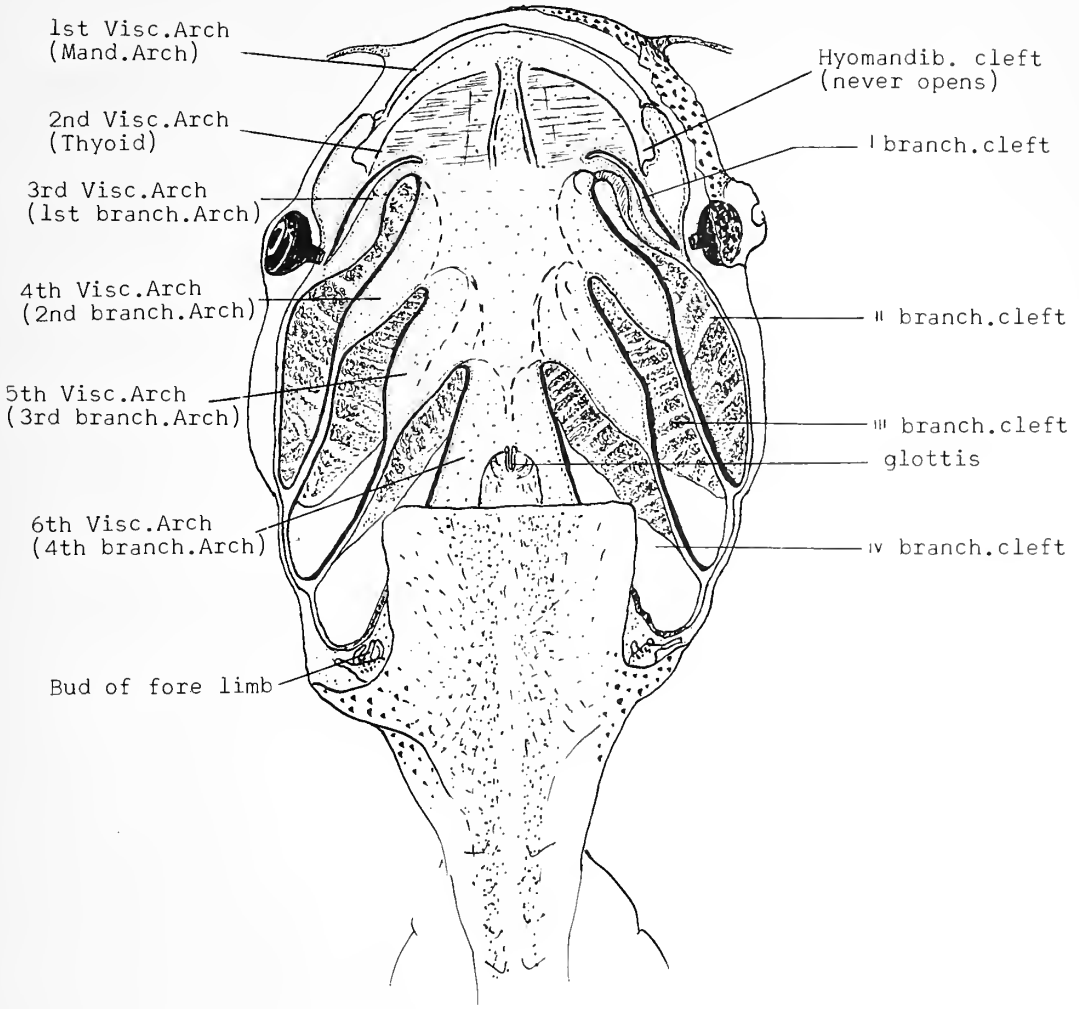

Fig. 3. Xenopus laevis, 7 cm tadpole pharyngeal floor x 4

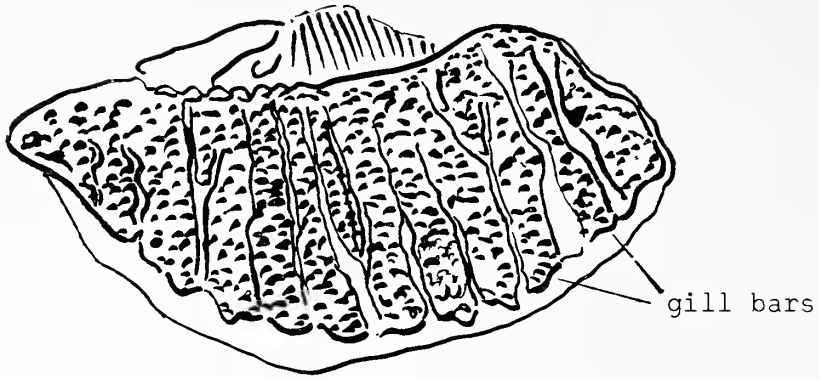

Fig. 4 Xenopus laevis, 7 cm tadpole
The posterior face of the 1st branchial arch septum, right side, shewing the appearance of the bars x 15

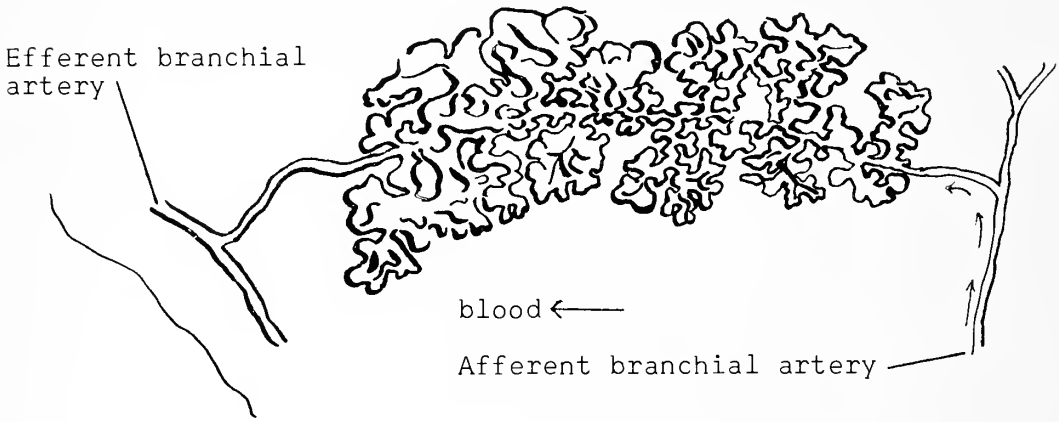

Fig. 5 Xenopus laevis, 7 cm tadpole
A single vertical commissure shewing the development of sacs on the posterior face of the first branchial septum x 70

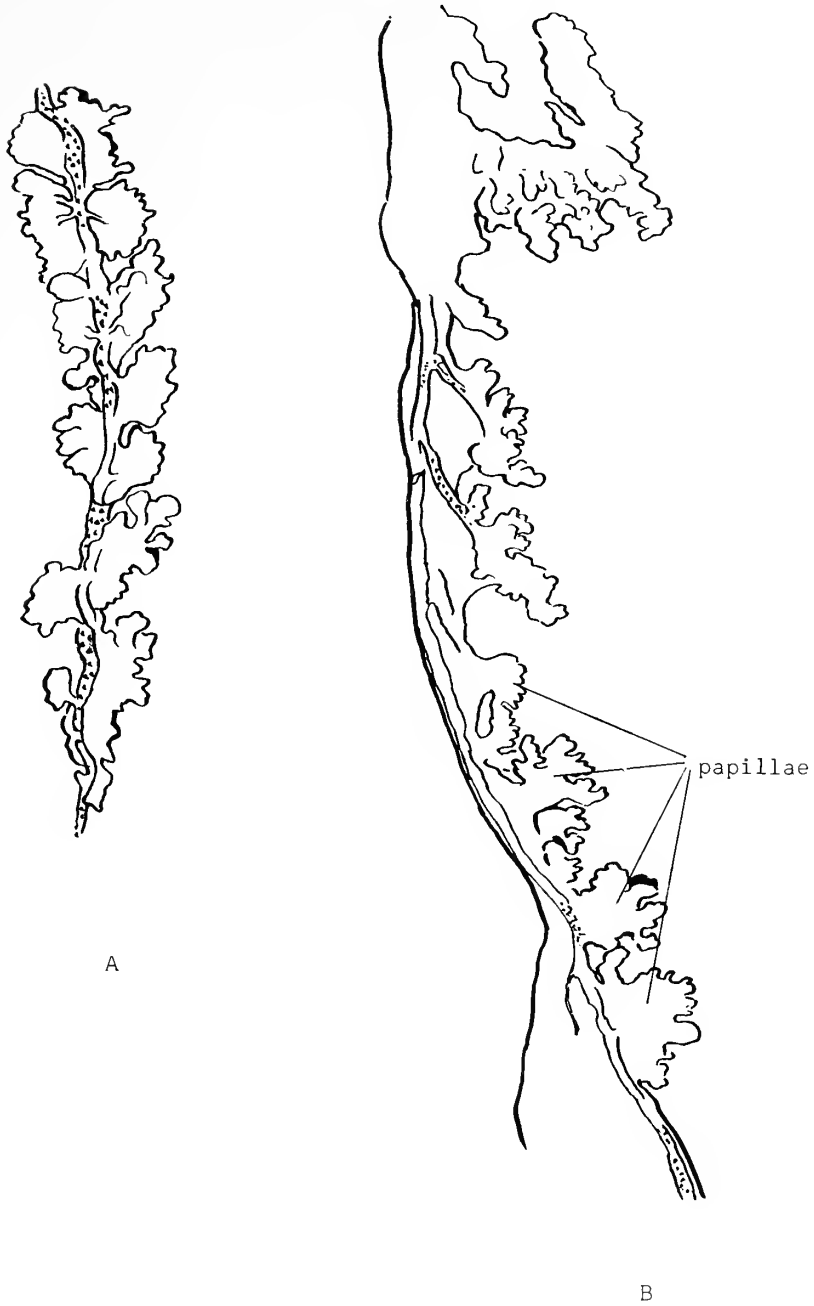

Fig. 6 Xenopus laevis, 7 cm tadpole

A: Horizontal section through fourth branchial septum x 23

B: Horizontal section through hemibranch of last branchial cleft x 23

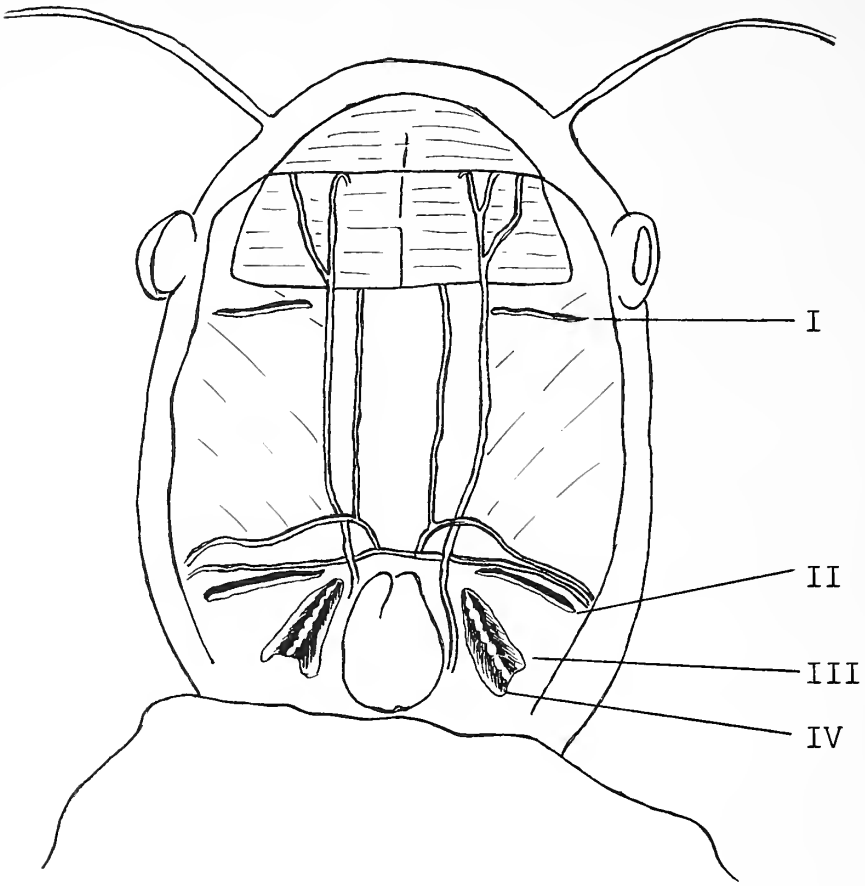

Fig. 7 Xenopus laevis, 7 cm tadpole
Ventral surface of head after removal of operculum, shewing openings into the branchial chamber x 2 1/2

A BREEDING RECORD FOR THE SOOTY TERN IN KENYA

By

J.B. SMART

The breeding status in Kenya of the Sooty Tern, Sterna fuscata Linnaeus, is not clearly defined in the literature. North (1945, p. 33) has previously pointed out that Jackson (1938, p. 427) makes a sole incidental reference to S. fuscata as being plentiful in July and August on the islands of the Kiunga Archipelago without making a definite statement that it was found breeding; Jackson (ibid, p. 435) also makes no reference to S. fuscata "on a small coral island off the headland between Lamu and Kipini" which is probably the Tenewe Islands. Moreau (1940, p. 50) makes no mention of S. fuscata in Kenya but later (1950, p. 425) indicates that it breeds on the Kiunga Islands in July and August, presumably inferring this from Jackson's reference. Available literature on the 1951 Oxford University Expedition to Kiunga (Anon, 1952, p. 10; Huxley, 1952, p. 533) makes no mention of S. fuscata, and Praed and Grant (1952, p. 435) does not record it breeding in Kenya. The 1961 Oxford University Expedition to Kiunga (Fogden, personal communication, 1963) also found no evidence of S. fuscata but this expedition did not visit all the Kiunga Islands.

On August 7th. 1963, the writer visited the Tenewe Islands, situated about one mile offshore and eleven miles to the south-west of Lamu Island, and found a breeding colony of about 5,000 pairs of S. fuscata. Birds were packed close together on the areas of short grass or shallow soil all over the islands above high tide mark. Most birds were incubating but there were a number of young birds which had not yet reached the flying stage, indicating that egg laying started towards the end of June. Many S. fuscata were also seen frequenting the Vinyika Rocks about five miles to the north-east of the Tenewe Islands but it was not possible to land there to confirm breeding. Colour photographs taken at the time show clearly the uniform sooty black upperparts, the absence of a pale collar round the hind neck and the white eyestripe reaching as far as but not behind the eye, characters which distinguish this species from the Bridled Tern, S. anaethetus Scopoli.

Praed and Grant (ibid) record S. fuscata as breeding on Mait Island in the Gulf of Aden, on Latham Island to the south east of Zanzibar Island and on Mafia Island off the Tanganyika coast. It also breeds in very large numbers in the Seychelles Islands (Ridley and Percy, 1958).

The probable absence of S. fuscata from the area south of Lamu and its possible presence in the Kiunga Islands to the north of Lamu in Jackson's time, considered in conjunction with more recent information and the present record, emphasises the uncertain and irregular breeding habits of the species.

The present record provides an interesting link in the breeding distribution of S. fuscata on the East African seaboard and helps to clarify its breeding status on the Kenya Coast.

In addition to S. fuscata, the Tenewe Islands contain a breeding colony of several hundred pairs of Noddy Tern, Anous stolidus Linnaeus; one pair of Roseate Tern, Sterna dougallii Montagu in breeding plumage and several Lesser Crested Tern, Sterna bengalensis Lesson, in non-breeding plumage were also seen but were not found breeding; one Bridled Tern, S. anaethetus Scopoli, was seen off the Vinyika Rocks.

The Tenewe Islands appear to contain the largest breeding colony of terns on the Kenya coast and would well repay further visits during the breeding season between June and September by anyone who can find a suitable reliable boat and who is prepared to risk the high seas at this time of the year.

I am grateful to M.E.W. North and J.G. Williams for examining colour photographs taken at the time and for confirming the identification.

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(Received 29th. June 1964)

A NEW SUBSPECIES OF PAPILIO PHORCAS Cramer

(LEPIDOPTERA, PAPILIONIDAE)

By

LUCIANO STORACE
(Museo Civico di Storia Naturale, Genoa.)

Papilio phorcas Cramer is a swallowtail butterfly widely spread throughout the forested areas of tropical Africa, from the western coast (Sierra Leone) to East Africa, excluding Ethiopia and the countries south of the Zambezi.

In the male, the ground colour of the wings is always black on the upperside and the markings are green; two types of the female are known, i.e.: a) the typical one, male-like, and b) the dimorphic form thersander F., dark brown with a yellow discal band and a complete series of yellow submarginal spots, on the upperside of the wings. Of these two forms, the male-like type occurs chiefly in West Africa, while the dimorphic female (thersander or the corresponding eastern forms) predominates from the Congo eastwards and southwards. Indeed, in the Congo the two types are known to occur together, but the male-like female is exceedingly rare.

The two sexes are tailed at vein 4 of hw., the tail being always more or less lobed, never straight and narrow.

Apart from the typical race, which ranges from Sierra Leone to Nigeria, several subspecies of this butterfly have been described, namely:

congoanus Rothschild 1896: Cameroons and Congo (dry-season form xera Storace 1955: Katanga)
niloticus Storace 1961: eastern Kivu, western and central Uganda.
ruscoei Krüger 1928: eastern Uganda and western Kenya.
ansorgei Rothschild 1898: Kenya highlands east of the Rift.
nyikanus Rothschild & Jordan 1903: Tanganyika.

Rather recently, Mr. R.H. Carcasson, the well known East African lepidopterist, Director of the Coryndon Museum, Nairobi, Kenya, has kindly submitted to me 2 ♂♂ and 1 male-like ♀ of this species from Nagichot, Didinga, S.E. Sudan, plus 1 ♂ from Moroto, Karamoja, eastern Uganda.

The comparison of these specimens to short series of the neighbouring races, leaves no doubt that the population of phorcas from Nagichot belongs to a new subspecies, still undescribed and unnamed.

PAPILIO PHORCAS Cramer, SUDANICOLA, ssp. nov.

Diagnosis: intermediate between the western phorcas and the eastern ansorgei; tails rather long and slender, thus approaching the western type; the green discal band on the upperside of the fw., rather narrow posteriorly and more or less strongly denticulated distad, except in

areas 1-a and 1-b; lacks the spot in interspace 5, as in ansorgei from the Kenya highlands. The single ♀ available is male-like.

Male (Holotype)

Measurements: wing-span, 78 mm.; forewing, base to apex, 46 mm. The upperside of the wings is distinctly black, as usual in this species, with all the green markings of a tone warmer than in ansorgei, congoanus, nilotica and typical phorcas. The green discal band runs from vein M2 to the posterior margin of the fw. (no green spot, therefore, in area 5, as in ansorgei) and is rather strongly denticulated distad, except in areas 1-a and 1-b; this band is rather narrower, even posteriorly than in the other western and eastern subspecies. An approach to this condition may be seen in nilotica. On the hw., the discal band is clearly produced distad in area 1-c. Unlike ansorgei and typical phorcas, there is a single dot in area 3, just outside the discocellular space (i.e., round vein DC, distally) of hw, which shows an almost complete series of greenish submarginal spots, shaded over with brown scales.

Female (Allotype)

Measurements: wing-span, 84 mm.; forewing, base to apex, 48 mm. Male-like ; differs from the Holotype as usual, in having lighter colours; upperside distinctly brownish, while the green markings are of a paler tone. The discal band, broader than in Holotype, is rather pale; no green discal spot in area 5 of the fw. An almost complete series of submarginal whitish spots, shaded over with brown scales, on all wings. Tails shorter than in the ♂, otherwise of western type.

Variation
The Paratype is quite smaller than the Holotype (measurements: wing-span, 74 mm.); forewing, base to apex, 42 mm. The discal band on the fw. even more denticulated distad than in the Holotype. Tails shorter than in the Holotype, otherwise rather western.

Holotype - ♂ - Nagichot (Didinga, S.E. Sudan), Sept. 3, J. P. Woodall;
Allotype - ♀ - Nagichot (Didinga, S.E. Sudan), Sept. 3, J.P. Woodall;
Paratype - ♂ - Nagichot (Didinga, S.E. Sudan), Sept. 3. J.P. Woodall.

Holotype and Allotype to be deposited in British Museum (Natural History)
Paratype to be deposited in Coryndon Museum, Nairobi.

The single ♂ from Moroto (Karamoja in Uganda, eastern Province), Oct.1952, B. Verdcourt leg., agrees rather well with the two males from Nagichot, but its tails are of eastern type (measurements: wing-span, 79 mm.; forewing, base to apex, 47 mm.).

The late Prof. G.D. Hale Carpenter, who worked rather extensively on the diurnal Lepidoptera from S.E. Sudan, did not quote this species from that area; in his paper of 1938 (see: Trans. R. ent. Soc. London, 87 : 217-232) he listed specimens of swallowtails from several localities, even from Nagichot, but none of Papilio phorcas.

Mr. Carcasson sent also two ♀♀ of this species collected at Kabogo Head, on the eastern shore of Lake Tanganyika, by the Kyoto University Primate Research Expedition (1).

These ♂♂ do not seem to agree with those of the known eastern races, but the material is inadequate to decide whether they belong to a new geographical entity, still undescribed and un-named. One ♂ shows the discal band on the upperside of fw. broader than usual posteriorly; it is also clearly transitional to the individual form casphor Suffert described from Tabora in Tanganyika (see: D.E.Z. Iris XVII, 1904, p. 27). In the Museum of Milan, I have seen one ♂ transitional to casphor from Gabon, on the West African coast.

According to Carcasson, in litt., the two ♂♂ from Lake Tanganyika appear to agree very well with specimens of congoanus Roths. from the Cameroons, while race nyikanus Rothschild & Jordan appears to be confined to the highlands of eastern Tanganyika and of Nyasaland.

My three specimens of congoanus from the Cameroons are very large and quite different, but I cannot exclude the occurrence, in that country, for instance in the Mandara area, of forms approaching those from Kabogo Head.

The two males from Lake Tanganyika do not agree with specimens of congoanus from the southern Congo (Katanga), nor with its dry form xera Storace, with the type of which they have been confused.

(1) For the locality of Kabogo Head, see:
Carcasson, R.H. - 1964 - New Butterflies from the Kigoma area of Western Tanganyika - J.E.Afr.Nat.Hist.Soc. XXIV, No. 4 (108): 62-67.

(Received 29th June 1964)

NATURE NOTES

A Remarkable Growth of *Lepiota*

The adjoining photograph shows a group of remarkably large fructifications of a species of *Lepiota* growing at Muguga, Kenya in April 1964. Interest in these toadstools was aroused when a specimen was collected in December 1963 and had a mean diameter, measured across the pileus, of 40 cm. The stipe measured 30 cm from the rhizomorphs to the lower surface of the gills and the whole toadstool weighed 680 grams.

From descriptions available to the authors, the toadstool was referred to *Lepiota americana* Peck, with whose description it agrees in all respects except that our specimens did not turn purplish-red on drying, but they did show pink colours when the fresh toadstool was broken. Peck gives only the type locality for his species and no information on its old world distribution is available to the writers.

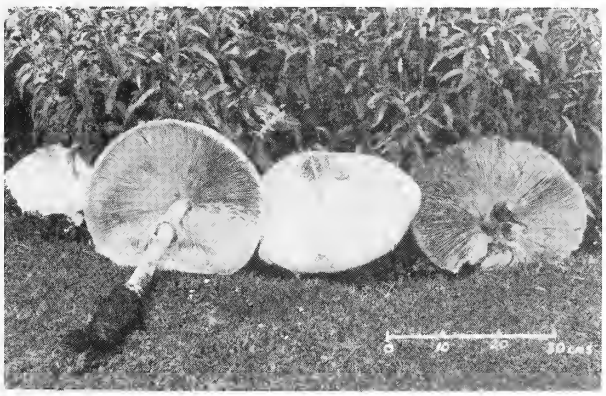
Some fructifications of this *Lepiota* appear at Muguga soon after the onset of seasonal rains but the large specimens do not develop until about 4-5 weeks after this, rather late in the season for agarics. They occur widely over the Muguga estate which lies on red soil at about 7,000 ft above sea level, and was under cedar and olive forest until about 1916 and repeated crops of Black Wattle *Acacia mearnsii* De Wild., from 1916 to 1952 when it was converted to many land uses.

A further excellent crop appeared in April 1964 when the photograph was taken. The two larger specimens measured 56 cm across pileus, stipe 38 cm, weight 800 grams and 42 cm, 38 cm and 750 grams, respectively.

We are indebted to Mr. D. Reid of the Herbarium, Kew, for a transcript of Peck's type description.

W.G. Dyson
I.A.S. Gibson

Kenya Forest Department.



Fructifications of *Lepiota americans* Peck. Muguga, April 1964.

(the coin is 3 cm in diameter.)

A Remarkable Gynandrous Carpenter Bee

A very unusual gynandromorph of Xylocopa nigrita Fabricius (Apoidea, Xylocopidae), was collected near Kericho, Kenya, by Master R. Arathoon in January 1964 and sent to the Coryndon Museum.

Gynandromorphs are supposedly uncommon in the Hymenoptera, but are probably frequently overlooked owing to the absence of marked sexual dimorphism in the majority of the more conspicuous species.

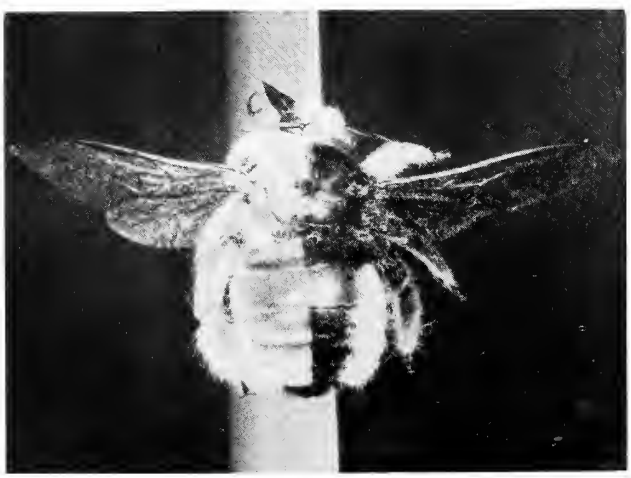
In Xylocopa nigrita the ♂ is uniformly pale reddish gold above and below, with rather smoky hyaline wings. The ♀ is velvety black, with silvery white frons, silvery white forelegs, and silvery white lateral margins to the abdomen; the thorax is black above, but silvery grey laterally and ventrally, and the second and third pairs of legs are black; the wings are sepia brown with a strong violet sheen in some lights.

Both sexes are large insects, measuring on the average 35 mm in length and 60 mm in wing span.

The specimen in question is an almost perfectly symmetrical bilateral gynandromorph, the left hand half being male and the right hand half female. The last segment of the abdomen is black, as in the ♀ and there are white hairs at the left hand margin of the 4th and 5th abdominal segments.

The underside of the insect is also symmetrically divided into a left hand male half and a right hand female half, but the ventral surface of the 4th, 5th and 6th abdominal segments shows the normal black and white female coloration; the genital armature is of the normal female type.

Unfortunately no records of the appearance in life of this extraordinary insect and of its behaviour are available.



R.H. Carcasson. 1/1/65

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